Nos. 118, 119

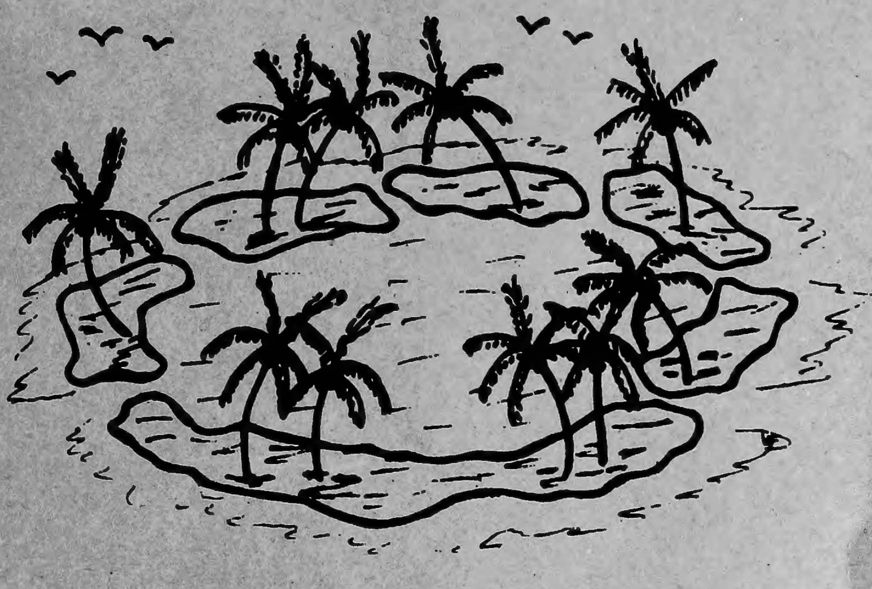
November 15, 1967

ATOLL RESEARCH BULLETIN

118. Ecology of Aldabra Atoll, Indian Ocean

edited by David R. Stoddart

119. Atoll News and Comment



Issued by
THE SMITHSONIAN INSTITUTION
Washington, D.C. U.S.A.

ATOLL RESEARCH BULLETIN

Issued by

THE SMITHSONIAN INSTITUTION, Washington, D.C., U.S.A.

November 15, 1967

ACKNOWLEDGMENT

The Atoll Research Bulletin is issued by the Smithsonian Institution as a part of its Tropical Biology Program. It is supported cooperatively by the Oceanography, Ecology, and Systematics Programs and by the Smithsonian Press. The Press handles production and distribution. The editing is done by the Tropical Biology staff in the Museum of Natural History.

The Bulletin was founded and the first 117 numbers issued by the Pacific Science Board, National Academy of Sciences, with financial support from the Office of Naval Research. Its pages were largely devoted to reports resulting from the Pacific Science Board's Coral Atoll Program.

Correspondence concerning the Atoll Research Bulletin should be addressed to the above, at the

Smithsonian Institution
Washington, D.C. 20560
U.S.A.

ATOLL RESEARCH BULLETIN

No. 118

Ecology of Aldabra Atoll, Indian Ocean
edited by Dr. David R. Stoddart

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D.C., U.S.A.

November 15, 1967

Contents

FIGURES

TABLES

PLATES (following page 141)

16. Incised pools and residuals on the platin surface, South Island, near Frigate Pool. The ground vegetation is Fimbristylis spathacea.

17. Surface exfoliation on platin near Frigate Pool, South Island. Some of the limestone sheets are completely detached. At the left of the photograph is a small area of mammillate limestone formed by secondary deposition.

18. Flat platin under open Mixed Scrub, showing residuals of brown limestone 3-4 ft high, near Flamingo Pool, South Island.

19. Brown-limestone residual 6 ft high, near Flamingo Pool, South Island. The surface of the residual shows solution furrows.

20. Seaward fringe of the Mixed Scrub community south of Takamaka. The vegetation is sparse, and almost all the shrubs and trees are dead, except for Pandanus.

21. Large tidal solution hole in champignon near Point Hodoul, South Island, being flooded by the rising tide. Note the basal solution notching on the islands.

22. Takamaka Pool, showing the large Ficus in which Pteropus aldabrensis is found.

23. Fresh water in a semi-permanent water-course at Cinq Cases, South Island, surrounded by dense Acrostichum aureum and Pandanus.

24. Freshwater pool used as a tortoise wallow, surrounded by Pandanus, on South Island, three miles southeast of East Channel.

25. Tortoises wallowing in a freshwater pool during the morning: one in the centre of the pool is dead.

26. Giant Land Tortoise, Testudo gigantea (Photo: R. Gaymer).

27. Tortoise on the dry floor of a freshwater pool, during the dry season, near Takamaka, South Island.

28. Tortoise and a Sacred Ibis, Threskiornis aethiopica abbotti, near Frigate Pool, South Island.

29. Frigate-birds diving for water at Frigate Pool, South Island.

30. Juvenile Red-footed Booby, Sula sula rubripes, on Polymnie (Photo: R. Gaymer).

31. Red-tailed Tropicbird, Phaëthon rubricauda rubricauda, on a lagoon islet inside East Channel.

32. Adult Sacred Ibis, Threskiornis aethiopica abbotti (Photo: R. Gaymer).

33. Colony of Sacred Ibis at Takamaka, South Island (Photo: R. Gaymer).

34. Flightless Rail, Dryolimnas cuvieri aldabranus (Photo: R. Gaymer).

35. Male Red-headed Forest Fody, Foudia eminentissima aldabrana, giving threat display in his territory. Note the dropped wings and tail, and raised head and rump feathers (Photo: R. Gaymer).

36. Pair of Flamingos, Phoenicopterus ruber roseus, wading in a brackish pool in mangrove on South Island (Photo: R. Gaymer).

37. Casuarina woodland at Anse Cèdres, South Island.

38. Coconut plantation, south end of West Island.

39. Settlement on West Island.

40. One of the rainwater tanks in the West Island settlement.

41. Fishing shack on Middle Island, at East Channel.

Chapter 1

SCIENTIFIC STUDIES ON ALDABRA ATOLL

D. R. Stoddart

Department of Geography, Cambridge University

1. The Ecology of Islands
2. Previous Investigations
3. Present Investigations
4. Acknowledgments

Atoll Research Bulletin No. 118: pp. 1-8 November 15, 1967

1. THE ECOLOGY OF ISLANDS

Oceanic islands have been recognised since the time of Darwin and Wallace to be of special significance in the study of biogeography and evolution. The work done in the past century, particularly in the Lesser Antilles, the Australasian archipelagoes, and the Hawaiian Islands, has permitted the formulation of general principles of dispersion, colonisation, and speciation in island biotas. By the time that these problems were being recognised, however, and hypotheses were being formed about them, many of the more accessible and congenial islands were being newly settled by man, with the resulting disruption of many unique assemblages of plants and animals by economic activities, or by the unexpected impact made by introduced species. This has happened particularly on the more accessible tropical islands, in many of which the opportunity to study undisturbed indigenous floras and faunas has gone for ever.

Much recent work on island ecology has, therefore, concentrated on those islands where disturbance has been minimal, particularly in the more remote and hostile environments of the southern cold temperature zone (Holdgate and Wace 1961; Wace 1965) (for all references see the "Bibliography of Aldabra", Chapter 6 of this Bulletin); on Amsterdam, Kerguelen, Crozet and St Paul in the southern Indian Ocean; on Macquarie, Auckland and Campbell Islands; and, in the south Atlantic, on Tristan da Cunha, Inaccessible and Gough Islands. Here the problems of insularity have been linked with that of the circumpolar distribution of many plants and animals (Pantin 1960; Darlington 1965). Within the tropics, classic studies have been carried out in the Galapagos Islands, initiated by Darwin himself and recently intensified since the opening of the Charles Darwin Research Station there (Bowman 1966). Other islands, including some in low latitudes, have been studied for the light they throw on the processes of replacement of native by introduced species, as in the case of St Helena and Ascension in the Atlantic Ocean, and Clipperton in the Pacific.

From these studies of islands, certain principles of island ecology emerge (Hesse and others 1951, 621-635; Darlington 1957, 476-544; Gulick 1932; Holdgate 1960; Carlquist 1965). First, islands are isolated by the sea, which acts as a barrier or filter of variable intensity for different groups of plants and animals, and the degree of isolation is a function not only of distance but also of the time available for colonisation: the older the island, the greater the probability that successful introduction has occurred. In this property of isolation we may include Wallace's distinction between oceanic and continental islands. Second, islands have limited area, and hence carrying capacity, which for larger animals may be less than a minimum threshold for survival, and they also possess unique environmental characteristics, particularly in climate. Work so far has concentrated on volcanic islands, such as the Tristan group, but coral islands, with a narrower range of environments, have the advantage for study of a simpler biota. Third, the combination of a peculiar environment with the fact that successful colonisation is dependent on a capacity for long-distance over-water dispersal and for survival in new habitats means that the biota of islands tend to be small and disharmonic. The absence of many continental genera and species means that competition is reduced,

and island species may increase their ranges. Infrequent colonisation and prolonged isolation favour the evolution of endemic varieties, species, and genera, especially on the older and larger islands such as Hawaii. Finally, the smallness of the biota, and its under-exploitation of the island environment, means that such communities are often unstable and are specially liable to large-scale disruption by invading alien plants and animals. This is well seen in the disappearance on many islands of large breeding colonies of sea birds, and of such ungainly creatures as the dodo, which are clearly unfitted to compete with introduced predatory mammals and competitors.

The islands of the Indian Ocean include granitic islands, volcanic islands, sea-level coral reefs and atolls, and islands formed of elevated reef limestones. Of the islands of coralline origin, the atolls have been studied in some detail at the beginning of the century, particularly in the Maldives (bibliography in Stoddart 1966, 107-122) and at Cocos-Keeling, on which Darwin worked and which has been studied more recently by Gibson-Hill (bibliography in Sachet and Fosberg 1955). The elevated limestone island of Christmas, near Java, was monographed by Andrews in 1900, and has been studied since. The high islands of the Andamans and Nicobars, visited by Seymour Sewell, have attracted comparatively little attention by comparison with those of the western Indian Ocean.

These latter, between the African coast and the approximate line of the mid-ocean ridge (Figure 1), are of considerable importance in the study of the geography and land ecology of islands. They include, besides the great landmass of Madagascar, the volcanic Mascarene Islands (Mauritius, Rodriguez, Reunion), the granitic Seychelles, the coral atolls extending from the Laccadives through the Maldives to the Chagos Archipelago, and the cluster of reef islands, many of them elevated, to the north of Madagascar, from Aldabra to the Amirantes and the Seychelles Ridge. Our knowledge of the biogeography of this area derives largely from a series of expeditions led by Professor Stanley Gardiner in 1899-1900, 1905, and 1908-09, culminating in the _Fauna and Geography of the Maldive and Laccadive Archipelagoes_ (Gardiner 1903-06) and in the eight volumes of _Reports of the Percy Sladen Trust Expedition_ (Gardiner 1907-36). Since Gardiner's work, several of the islands, particularly in the southwest Indian Ocean, have been devastated beyond the possibility of further useful work, mainly by guano diggers, and even when he wrote, many of the most interesting forms, such as the giant flightless land birds of the Mascarene Islands and the giant land tortoises of the southwest Indian Ocean, had been hunted to extinction or near-extinction by man and his introduced predators.

Of the elevated reef islands of the western Indian Ocean, only Aldabra has escaped massive interference by man. By contrast, the guano reserves of nearby Assumption have been mined for many years, and this applies also to St Pierre, Astove and others (Baker 1963, 110-127; review by Hutchinson 1950; and Chapter 3 of this Bulletin). The lack of economically workable guano deposits on Aldabra, together with an environment unsuited to agriculture or even to human settlement, has meant that here isolation has continued to the present day.

The ecology of Aldabra is of interest for three main reasons. First, it is an uplifted atoll, and hence provides a wider range of habitats than most

sea-level reef islands. Second, it is oceanic, in the sense that there is no evidence of any former land connections with continental areas, and hence the biota must have been derived by normal dispersal processes; but at the same time its relative proximity to Africa, and particularly to Madagascar and the Comoros, means that the probability of successful colonisation from these sources has been high. Combined with the diversity of habitat, this has produced a fauna and flora exceptionally rich for a coral atoll. And third, its isolation has not only led to the development of endemic species of both plants and animals, but has favoured the development or survival of such creatures as flightless land birds and the giant land tortoise. With the devastation of nearby islands which originally possessed very similar ecosystems, Aldabra is thus of special importance in the category of elevated coral atolls. Most of the similar high limestone islands in the Pacific have been devastated for guano (Ocean Island, Nauru, and Makatea being the worst examples), and those which remain (such as Henderson and Vostok) are so far from continental land as to be biologically impoverished. Scientific understanding of elevated reef-limestone islands can thus only be obtained by detailed work on Aldabra Atoll.

2. PREVIOUS INVESTIGATIONS

Much early information on Aldabra was frankly speculative, and once it appeared in the literature it was repeated by many authors. Horsburgh, for example, states that "from the appearance of these islands, water is perhaps plentiful, and also timber of sufficient size to be useful to any ship in distress for spars" (Horsburgh 1852, 176), and according to Pridham (1846, 307) "water would appear to be plentiful". Opinions such as these were clearly not based on any real knowledge of the atoll.

Table 1 lists the scientific expeditions, official parties, and some of the more significant individuals to visit Aldabra since the first hydrographic survey in 1878. Of these investigations, four resulted in large collections of flora and fauna: those of Abbott in 1892, of Voeltzkow in 1895, of Dupont in 1906 and on several later occasions, and of Fryer in 1908-09, in connection with Professor Gardiner's last expedition. The most important general memoirs are those of Voeltzkow (1897, 1902), Dupont (1907), and Fryer (1911), and an outline of the salient features of the ecology of Aldabra has been given by Stoddart and Wright (1967a). More detailed papers are referred to in this Bulletin, and an attempt to give a complete bibliography is made in Chapter 6. Early voyages to Aldabra, with comments on the origin of the name, are listed by Voeltzkow (1897, 40-41).

In recent years, mention must be made of Ommanney's visit in 1948 and the popular account he later wrote (Ommanney 1954); of the visit of the Calypso, Commander J.-Y. Cousteau, in 1954, which resulted in large additions to our knowledge of the birds, crustacea and Lepidoptera; and of the Bristol Seychelles Expedition in 1964-65. This party, led by M. J. Penny, visited Aldabra first between 11 November and 14 December 1964; a second visit was made by one member, R. Gaymer, between 4 October and 20 November 1965.

Table 1.--Previous Investigations at Aldabra

Date	Investigator	Field of Study	General Publication
1878 July	H.M.S. Fawn, Dr. Wharton	Survey	Wharton 1879, 1883
1892 May	H.M.S. Redbreast, Mr T. R. Griffith	General	Fairfield, Griffith and Abbott 1893
1892 Sep-Dec.	Dr W. L. Abbott	Birds, insects, plants	Abbott 1893
1895	Mr Wilson	Molluscs	Von Martens and Wiegmann 1898
1895 Apr-May	Dr A. Voeltzkow	Geology; all groups	Voeltzkow 1897, 1902b
1904 Dec.	Mr F. R. Mortimer	Birds	-
1905	Anon.	General	Anon. 1920
1906 May	Valhalla, Lord Crawford	Birds, insects	Nicoll 1908, 114-123
1906 Oct-Nov.	Mr R. P. Dupont	Plants, insects, birds	Dupont 1907
1907	Mr H. P. Thomasset	Insects, birds	-
1908 Aug.-1909 Feb.	Mr J. C. F. Fryer	Geology; all groups	Fryer 1910, 1911
1916	Mr W. Fox	Botany	Hemsley 1919
1937 Oct.	Mr D. Vesey-FitzGerald	Birds, vegetation	Vesey-FitzGerald 1940, 1941, 1942
1948	Seychelles-Mauritius Fisheries Survey Mr J. F. G. Wheeler Dr F. D. Ommanney	Commercial fisheries Turtles	Ommanney 1952, 258-294; Wheeler and Ommanney 1953
1953 Nov.	Italian Zoological Expedition: C. Prola, F. Palombelli, F. Prosperi, S. Nievo	General; insects	Prosperi 1955, 1956, 1957; Berio 1956, 1959

Table 1. --(continued)

Date	Investigator	Field of Study	General Publication
1954 May	Calypso, J.-Y. Cousteau G. Cherbonnier	General, crustacea birds	Cousteau 1959, 1963
1956	Mr W. Travis	Turbo	Travis 1959, 157-193
1957 Dec.	Yale Seychelles Expedition Dr A. J. Kohn Dr W. D. Hartman	General, tortoises	
1959	H.M.S. Leopard	Birds	Boulton 1960
1959	Mr H. Legrand	Lepidoptera	Legrand 1965
1960 Sep. 1961 Jan.	Dr B. H. Baker, Mr C. J. Piggott	Geology	Baker 1963
1962 Jan.	H.M.S. Owen	Birds	Morris 1963
1964	R. E. Honegger	Birds, tortoises	Honegger 1966a, b
1964 Mar.	H.M.S. Owen	Birds	Bourne 1966
1964 Nov.-Dec.	Bristol Seychelles Expedition: M. J. Penny, C.M. Penny, R. Gaymer, R. Blackman, P. G. Dawson	Birds, tortoises	Blackman 1966
1965 Oct.-Nov.	R. Gaymer	Birds, tortoises	Gaymer 1966b
1966 Sep.-Oct.	Dr D. R. Stoddart Dr C. A. Wright	Geomorphology, land ecology	Stoddart and Wright, 1967a

3. PRESENT INVESTIGATIONS

Aldabra has recently been considered as a possible site for the construction of a military airfield by the Ministry of Defence. With the co-operation of the then Minister of Defence for the Royal Air Force, Lord Shackleton, and of the Hydrographer, Rear-Admiral G. S. Ritchie, it has been possible, with the support of the Southern Zone Research Committee of the Royal Society, to

begin detailed investigation of the geography and land and marine ecology of Aldabra, for the purposes of preparing long-term conservation plans and of gaining knowledge of this unique island ecosystem. Dr C. A. Wright and the author were attached, in September and October 1966, to the British Broadcasting Corporation's Expedition Turtle, as a result of which further investigations are now being planned. This Bulletin has been designed to summarise present knowledge of Aldabra, within the framework of the work carried out during the 1966 expedition. Chapter 2 covers the whole range of geography and ecology, so far as is known. Chapter 3 summarises the very scanty and often old information on the islands near to Aldabra, to provide comparative data for the assessment of the importance of Aldabra itself. In Chapter 4 Mr C. W. Benson presents a full analysis of the birds of the atoll and the neighbouring islands, with special reference to the land birds, based on his own field experience in the Comoro Islands and an exhaustive study of the collections made by Abbott, Voeltzkow, Dupont and others. Chapter 5 presents some observations by Mr R. Gaymer, made during his two visits as a member of the Bristol Seychelles Expedition, on the natural history of the birds, again with reference to the land birds. Finally, Chapter 6 gives a full bibliography. It is intended that this account will not only stimulate scientific interest in this too-much neglected atoll, but will serve as a working paper for the project of further investigations now being planned.

From our knowledge of the biota, it is clear that the importance of Aldabra stems first of all from its population of the giant land tortoise, a relic of a once wider population which demands both urgent study and effective conservation, and second, from the isolation of the atoll and the distinctive assemblage of both plants and animals which has formed as a result. Many species of both plants and animals may be distinct; and it was on such endemic species that scientific interest at Aldabra, as indeed in most insular biotas, formerly centered. Some of the endemics, such as the rail Dryolimnas, last flightless bird of the Indian Ocean islands, are of special concern, but their interest is far below that of the giant tortoises. More important from an ecological viewpoint are the island populations of more widely ranging species, particularly the great colonies of frigate birds and boobies, and the breeding populations of the migratory green turtle. Other species, while probably not distinct, no longer exist in large numbers, and efforts must be made to preserve them before they disappear: this applies to the Sacred Ibis, and particularly to the Flamingo.

With the possibility of military development, these problems immediately become acute: for while we already know a great deal about the composition of the biota, in the sense of lists of plants and animals, we know very little about the island ecology and its areal variation. Many ecological problems, such as those of food chains and population structure, cannot be adequately studied during brief visits. The realisation of the scope and importance of purely ecological problems, as opposed to taxonomic ones, coincides, furthermore, with a changing emphasis in island biology, from the simple recognition of peculiar species to the study of the genetics of change in remote, insular populations (Carlquist 1966). Studies in population genetics again require detailed long-term work. It is not too much to say that only now are theoretical concepts becoming available which can enable us to understand structure,

function, and change in island ecosystems, but by this time few island ecosystems remain to be studied.

The Royal Society, with the active assistance of the Ministry of Defence, and following a conference in London in January 1967 attended by many scientific and conservation organisations from Britain and the United States, is organising a programme of further scientific work at Aldabra in 1967-68. The Royal Society Expedition to Aldabra 1967-68 will consist of three parts. The first, in August and September 1967, during the dry season, will concentrate on further land reconnaissance, and on lagoon ecology. A resident party to carry out long-term studies of the sea bird colonies, of the land birds, of the lagoon biota, and of the tortoises and turtles, will remain on the atoll for the second part of the expedition, from August 1967 to March 1968, some members spanning both wet and dry seasons. Finally, in January to March 1968, the third part of the expedition, a wet-season party will concentrate on land flora and vegetation and land zoology. By the end of this programme, enough data will have been gathered to serve as a permanent record of an unspoiled oceanic island, and as a basis for meaningful conservation measures if military development takes place. If, on the other hand, military development is averted, then this scientific project will provide a base-line for continuing studies of this remote and still largely unspoiled unique island ecosystem.

4. ACKNOWLEDGMENTS

Thanks are due first of all to the Ministry of Defence, and to Lord Shackleton, former Minister of Defence for the Royal Air Force, and Rear-Admiral G. S. Ritchie, Hydrographer, for their active assistance and co-operation in making scientific participation in the 1966 expedition possible; to the British Broadcasting Corporation and the leader of the expedition, Mr A. Bosworth, for giving Dr Wright and myself every facility and aid on Aldabra; and to the Royal Society for their interest and support. Dr Wright and I are also grateful to Mr C. E. Loveridge, Ministry of Public Buildings and Works, Wing-Commander P. A. S. Thompson, Ministry of Defence, Mr G. Dawson, British Broadcasting Corporation, and other members of the expedition for their help and companionship in the field, and to the late Professor C. F. A. Pantin, F.R.S., for his initial encouragement. We thank the Director of the Royal Botanic Gardens, Kew, Sir George Taylor, for the loan of equipment and for the identification of the botanical collections by members of his staff (Dr J. P. M. Brenan; and Mr Clayton, grasses; Miss Hooper, sedges; Dr Jarrett, fern; and Mr Bullock, other groups). I am grateful to Professor H. C. Darby and the University of Cambridge for temporary leave of absence for part of the expedition.

I am also grateful to Mr C. W. Benson and Mr R. Gaymer for their contributions to this Bulletin. Mr Gaymer, who visited Aldabra twice with the Bristol Seychelles Expedition, has very generously allowed me to read his unpublished memoranda and papers based on his work during that expedition. Lady Joan Fryer, widow of the late Sir John Fryer, whose memoir on Aldabra is still the most useful account available, has very kindly loaned me Sir John's manuscript journal and other papers to do with his visit to Aldabra in 1908-09.

I thank also Dr F. R. Fosberg and Dr Marie-Helene Sachet for their interest and advice on the conservation of Aldabra during the last several years.

Dr W. R. P. Bourne has read the whole manuscript of this Bulletin and has made many most useful suggestions. Other sections have been read by Dr F. C. Fraser and Mr John Peake of the British Museum (Natural History) (Chapter 2); Dr F. R. Fosberg, Smithsonian Institution (Chapter 2); and Dr R. E. Moreau, Edward Grey Institute, Oxford, and Dr G. E. Watson, Smithsonian Institution (Chapter 4).

Mr Daniel Labworth very kindly gave permission for the quotation of sections of the commercial lease agreement for Aldabra, signed in 1955, used in Chapter 2.

Finally, I am grateful to Miss R. King, who drew the maps; Mr R. Coe, who made the prints; and to Mr R. Balmforth, who carried out a very great deal of xerox work in connection with this project.

Chapter 2

GEOGRAPHY AND ECOLOGY OF ALDABRA ATOLL

D. R. Stoddart

Department of Geography, Cambridge University and

C. A. Wright

Department of Zoology, British Museum (Natural History)

Atoll Research Bulletin No. 118: pp. 11-52 November 15, 1967

1. LOCATION AND REGIONAL SETTING

Aldabra Atoll (latitude 9°24'S., longitude 46°20'E.) lies 260 miles northwest of Madagascar and 400 miles from the East African mainland. With the adjacent islands of Assumption and Cosmoledo, it rises as an isolated mountain in a basin 2000-2500 fathoms deep, bounded to the west by the African coast, to the south by Madagascar and the Comoros, and to the east by the Farquhar and Amirantes Banks and the Seychelles-Mascarene Ridge. Farther north, this basin has been shown to contain thick sequences of sedimentary rocks and to have a normal crustal structure (Francis and others 1966). The Seychelles-Mascarene Ridge, clearly defined by the 2000 fathom isobath (Figure 1), appears to be of complex structure. The Seychelles Bank itself is underlain by Pre-Cambrian granite, which emerges to form the main islands (Baker and Miller 1963; Matthews and Davies 1966). Matthews believes, from geophysical evidence, that similar rocks, with later basic dykes, are found between the Seychelles Bank and the Saya de Malha Bank, and again underlying Cargados Carajos Shoals near the southern end of the Ridge. Conversely, the Amirantes ridge, southwest of Seychelles, is

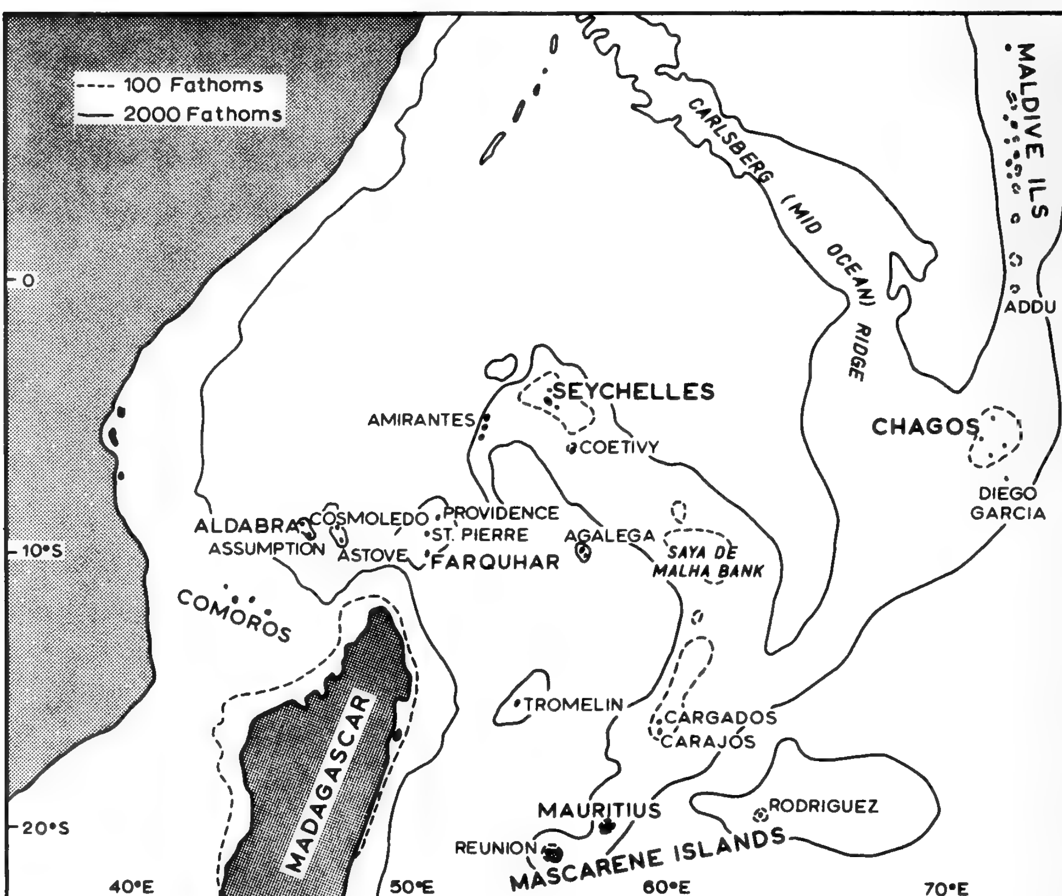


Figure 1.--Location of Aldabra

thought to consist of a coral capping, less than 1 km thick, overlying a basaltic volcanic arc (Matthews and Davies 1966). The Saya de Malha Bank itself, near the middle of the mid-ocean ridge, is also thought to consist of volcanic rocks capped with coral (Shor and Pollard 1963), and the islands of Mauritius and Réunion are themselves volcanic. South of Aldabra the Comoro group consists of a series of volcanoes of different ages (Guilcher and others 1965), and large areas of the Madagascar granites are covered with volcanics.

Little is know of the crustal structure north of the Comoros, or between Aldabra and Farquhar and Madagascar and the Amirantes. The conclusions of earlier biologists, concerned with problems of distribution, calling for isthmian links and drifting continents, are no longer tenable. Although geophysical evidence is lacking, the isolated nature and considerable relief of the mounts of the Aldabra group, rising steeply from uniform depths of c. 2200 fathoms, together with the proximity of recent volcanoes in the Comoros, suggests a volcanic basement at undetermined depth beneath the islands. This interpretation is supported by the presence of fragmental basalts, similar to rocks from Madagascar, associated with foraminifera of Eocene-Oligocene age, from the slopes of Providence, 300 miles east of Aldabra, at a depth of 744 fathoms (Wiseman 1936), and by the similar trends of both the Aldabra and Comoro ridges. This may imply the former existence of high volcanic islands, similar to the Comoros, perhaps in the early Tertiary, at Aldabra, Assumption and Cosmoledo, and also at Farquhar, Providence and St Pierre, and their transformation into atolls by Darwinian subsidence.

Apart, therefore, from the Comoros, the volcanic Mascarene Islands, and the granitic Seychelles, the islands of this western sector of the Indian Ocean are of reef origin. They include either sand cays of reef debris on sea-level reefs, as in the Amirantes, Cargados Carajos, and the Chagos Archipelago, or islands formed of uplifted reef limestones, as at Aldabra, Astove, Assumption, St Pierre, Providence, Cosmoledo and Farquhar. Baker (1963) has described the geology of many of these smaller islands, and their distribution is shown in Figure 2.

The date of uplift of the raised reef islands, including Aldabra, is unknown. Contrary to earlier ideas, based on Daly's hypothesis of Holocene high stands of sea-level, it has now been shown that many elevated reefs, formerly thought to be of post-glacial age, are in fact Last Interglacial. Veeh (1965, 1966), using uranium-series radiometric dating techniques, has shown that elevated fringing reefs at Mahé and Praslin in the Seychelles and at Gabriel Island, Mauritius, at 9, 6 and 2 metres respectively above present sea-level, have ages of 140, 140 and 160 thousand years. Dates of low elevated reefs from Hawaii, the Tuamotus, the Cook Islands, and western Australia (all reported by Veeh 1965), and from Florida and the Bahamas (Osmond and others 1965; Broecker and Thurber 1965), are all greater than 80,000 years, and cluster round 130,000-150,000 years B.P. This suggests that many elevated reefs were formed during the Last Interglacial and have emerged subsequently, perhaps eustatically. This simple picture must be complicated locally by earth movement, but it provides a tentative time-framework into which the elevated Aldabra group of islands may fit. The freshness of the raised reefs at Aldabra itself suggests that the time-scale may be too long, and material has been collected for radiometric dating. There is

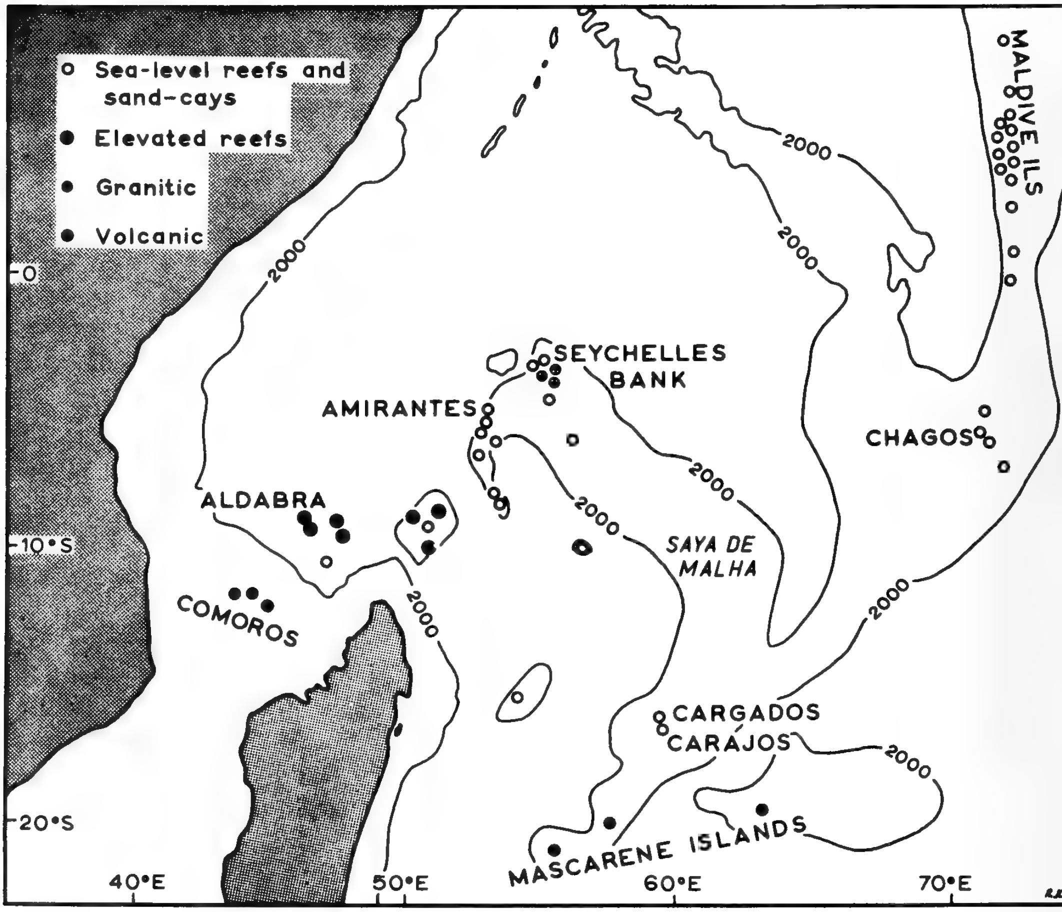


Figure 2.--Geology of Indian Ocean Islands

certainly no basis for Travis's statement (1959, 170) that the age of Aldabra is less than 3,500 years.

No climatic records are available for Aldabra, though a wartime station was established at Agalega, 450 miles to the east (Newnham 1945), and another has been established at Tromelin. The period May-November is that of the South-east Trades, and is dry; December-April, during the north-west monsoon, is a period of calms, oppressive weather, and rains. Estimates of total rainfall vary from 15 inches per annum (Vesey-FitzGerald 1942, 1) to 90 inches. Dupont in 1906-7 recorded 34 inches between October and January, with 25 inches during 17 days in January alone, when the wet season had just begun (Dupont 1907, 18). The mean annual total may thus be of the order of 50-60 inches. Mid-day temperatures are generally 85-90^{o}F., and night temperatures may fall to 70^{o}F. Aldabra lies to the northwest of the Indian Ocean belt of tropical cyclones, but it is occasionally affected. Perhaps the closest on record is that of February 1898, which passed over the atoll. Spurs (1892) mentions the defoliation and killing of vegetation during cyclones, and Fryer (1908-9) describes mangroves defoliated in 1907, but these must be rare events. Other cyclones have passed close by the atoll in recent years, but their effects have not been recorded.

2. GEOMORPHOLOGY AND GEOLOGY

Aldabra Atoll (Figure 3) is an elevated atoll, elongated east-west, with a maximum length of 21 miles and a maximum width of 9 miles. Its total area, bounded by the edge of the peripheral reef flat, is 141 square miles, and of this, land occupies 60 square miles. The land rim consists of four main islands (for a discussion of place names on Aldabra, see Section 7 of this paper: the asterisk attached to names in this paragraph indicates the name used in this report): South Island*, also known as Main Island and Grande Terre (42.5 sq. miles), Middle* or Malabar Island (10.2 sq. miles), Polymnie* (0.7 sq. miles), and West Island* or Ile Picard (3.6 sq. miles).

West Island and Polymnie are separated by Main Channel*, 1000 yards wide and carrying 10-12 fathoms at its entrance, and Middle and South Islands by the narrower East Channel* or Passe Houareau. Both of these channels are made dangerous for navigation by rapid tidal currents, and East Channel in particular is short and narrow. Main Channel branches dendritically lagoonward, and its branches maintain depths of up to 3-5 fathoms for 4 miles from its mouth. Johnny Channel*, between Polymnie and Middle Islands, unlike Main and East Channels, is a gap in the land rim rather than in the peripheral reef platform, which has been subsequently scoured out by tidal rips to a depth of 4 fathoms. West Channels* (Passe Lanier), between West and South Islands, are shallow gaps of recent origin eroded through a narrow sector of the land rim; they do not transect the reef platform. Of the West Channels, several of the individual passes between the small residual islands are named (Passes Femme*, Dubois*, Magnan*, Grabeau*); Passe Dubois is the deepest and is navigable by small craft and pirogues at high water.

In addition to the main rim islands, there are numbers of smaller islands within the lagoon, mostly close to the land rim and often connected to it at low water. These lagoon islands are concentrated along the south shore of Middle Island and along the eastern lagoon shore of South Island. Within the lagoon itself there are only two large islands: Ile Esprit* or Euphrates Island (0.13 sq. miles), with its tiny adjacent Ile Sylvestre* in the west, and Ile Michel* or Coconut Island, 0.16 sq. miles, in the east. The lagoon itself is shallow, and navigability depends entirely on the state of the tide. This has a maximum range of approximately 11 feet and is semi-diurnal: at low water springs, much of the eastern part of the lagoon, together with a fringe along its southern side, dries out, exposing mud flats and sandbanks; over the rest, Admiralty Chart 718 plots soundings of not more than 1 fathom in the inter-distributary areas of inner Main Channel. Because of the large area of the lagoon and the small and restricted entrances, there is a considerable lag in tidal behaviour within the lagoon compared with outside it: at springs the tide is still flooding in the Bras Takamaka* when it has begun to ebb outside.

1. Coastal Morphology

(a) Seaward side

The land rim is surrounded on its seaward side by n intertidal or slightly subtidal platform, which is narrowest (down to 100 yards) on the east or windward side, averages 200-300 yards in width along the north and south coasts,

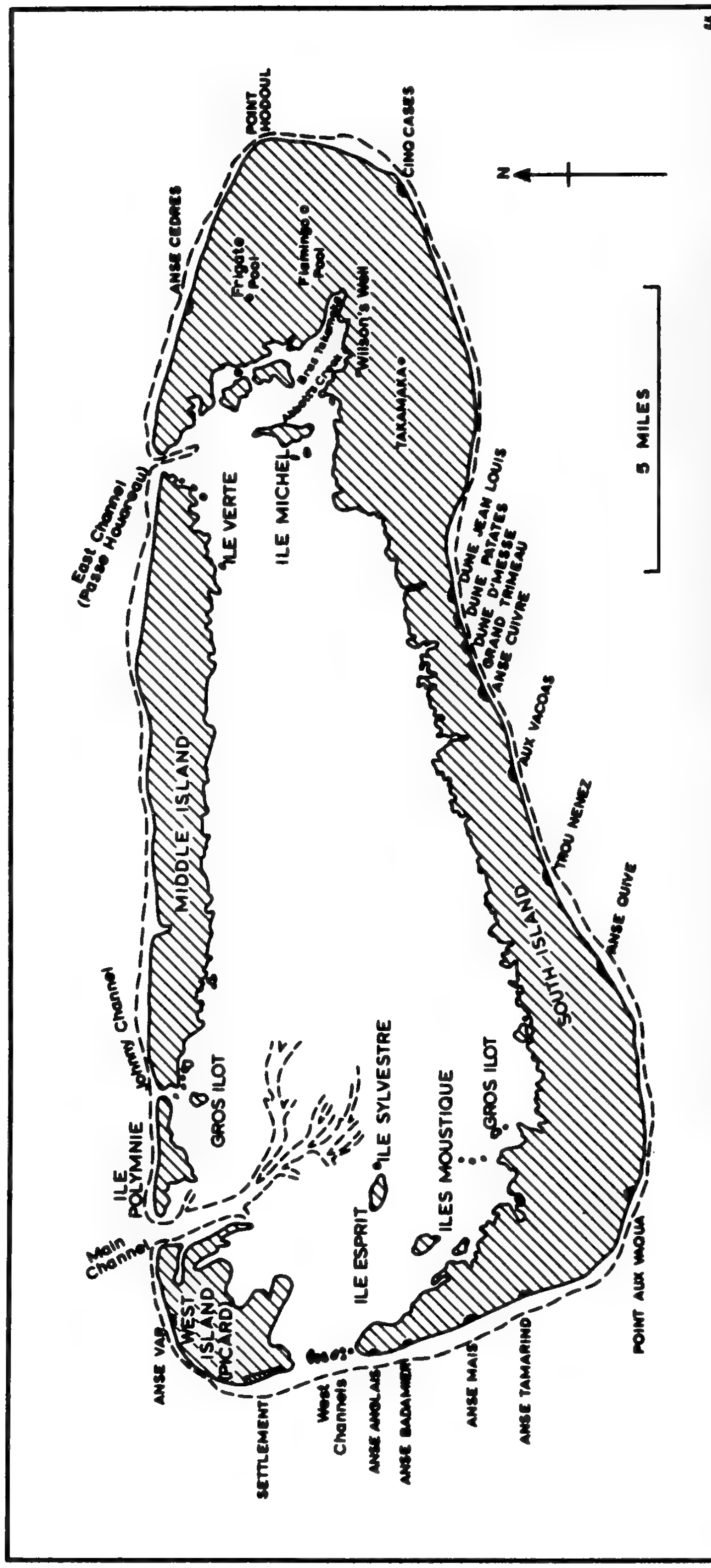


Figure 3.--Aldabra Atoll

and reaches 500 yards on the sheltered west coast. According to Travis (1959, 163), the reef front falls gently from the edge of this platform to a depth of 70 feet, before falling steeply to great depths, and this upper slope is marked by furrows 2 feet wide and 1 foot deep. The upper seaward slope may thus be equivalent to the 10 fathom terrace identified on many other atolls. Depths greater than 100 fathoms are generally found within half a mile of the edge of the intertidal platform, except at the east end, off Point Hodoul, where a shelf of bare limestone and algae extends seawards for two or three miles with depths of 20-25 fathoms (Travis 1959, 163).

The intertidal platform itself is an erosional feature formed of planed reef-rock with a thin, discontinuous sand cover and mats of Cymodocea, and is not a primary reef flat formed by contemporary reef growth. The seaward edge is marked by an intermittent boulder zone on the windward side (Plate 3), but there is no algal ridge, in contrast to the reefs of the central Indian Ocean (Stoddart 1966, 17). Baker (1963, 110) has argued that the platform is a growth feature, since if it were erosional it would be widest in more exposed locations. This misconceives the erosional process, however, which is mainly solutional and biological, rather than abrasional, and hence not so directly dependent on wave energy. His second point, that it must be a growth feature because it continues into the channel entrances, does not follow. The planed-rock surface cannot be a simple growth feature, nor could it form by reef growth at its present level, which dries at low water springs. No living corals were seen on the flat between East Channel and Anse Cèdres, nor at the seaward side of West Island. Fryer (1911, 413-414) suggested an erosional origin, and this is supported here. There is no information on reef growth on the seaward slope, though reef-blocks and cobbles suggest that Heliopora is important.

The inner margin of the intertidal flat or platform is generally formed by low retreating limestone cliffs in which corals are exposed. The cliffs rise to 15 feet above the platform in the east of the atoll, and to slightly lower in the west. Two distinct cliff morphologies may be recognised, the exposed type and the medium-energy type:

(i) Exposed Type

Locality: seaward coast from Takamaka to Point Hodoul. Here the cliff form is indistinct and ramp-like, rising at a high angle from a narrow basal intertidal platform with rimmed pools (Plate 1). The main peripheral reef platform appears to be at a lower level here than elsewhere, and surge breaks over the rimmed-pool platform, which is less than 3 yards wide and is coloured reddish-brown with algae. The upper part of the cliff-ramp is deeply and intricately dissected by salt-spray solution holes. There are no beaches. This type is homologous with several exposed shore profiles under study on elevated reefs of the southwest Pacific.

(ii) Medium-energy Type

Locality: Point Hodoul to East Channel, and the north coast of Middle Island. Here sea conditions are less extreme, and the dominant process is solutional: the cliff is vertical, deeply undercut by an intertidal solution notch, and the intertidal rimmed-pool platform is absent (Plate 2). The

notch has an amplitude at its mouth of not less than six feet; and the deepest notches extend back under the cliff for up to 30 feet. Small sand and cobble beaches may form within these deep notches, and are characteristically blue-coloured from their Heliopora content. Water constantly drips from the notch roof, where deposition may be taking place. Above the notch the cliff face rises vertically for 6-9 feet, and at the curve-over to the land surface it is intricately dissected by salt-spray solution cups. Occasional blowholes connect the land surface with the deeper notches. While the notch-forming process is clearly chemical and biological rather than mechanical, and analogous to that described from the Red Sea by Macfadyen (1930) and Guilcher (1955), the undercutting frequently leads to failure and collapse of sections of the cliff face. In plan, the recession process forms micro-headlands and bays, but the outline is surprisingly regular and outliers and residuals are rare. Immediately at the base of the cliff, between the notch and the intertidal platform, there is often a linear depression which may be up to 2 feet lower than the platform itself. This is probably partly excavated by mechanical action, and partly by increased solution associated with turbulence, at times of high water; at low water springs the notch is completely exposed, and at high water springs the sea reaches its upper lip.

Beaches are rare. In places, uneven cliff-retreat has formed small coves with "pocket beaches" (Plate 4), locally known as anses (the "lances" of Fryer 1911, 402). At Anse Cèdres (Plate 5) the beach is less than 100 yards long, with a 10^{o} slope, and a low-water width of 50 yards. Half the beach is lined with beachrock outcropping at high water level. Similar pocket beaches are reported on the south coast of Aux Vacoas, Trou Nenez and Anse Quive, but have not been visited: it is possible that at some of these locations the sand is so extensive that locally it covers the cliffs and joins the beach to the dunes above. At the east end of South Island, small perched beaches up to 3 feet in thickness are found on the cliff-top 15-20 yards inland from the edge (Plate 4). These are clearly storm deposits with much Halimeda. On the leeward side of the atoll, beaches are more extensive, as at Anse Mais, Anse Badamier, and Anse Anglais; and along the southernmost mile of the seaward coast of West Island beach deposits almost completely blanket the underlying raised reefrock (Plate 38). At the settlement itself the beach rises to a height of 15 feet above the intertidal platform, and has basal beachrock several hundred yards long and several yards wide.

Dunes are developed along much of the south coast of South Island, from Point Hodoul westwards. Between Point Hodoul and Takamaka the dunes are narrow and low, only locally exceeding 6 feet in thickness (Plates 6-8); further west, at Grand Trimeau, Dune d'Messe, Dune Patates and Dune Jean Louis, isolated dunes rise to heights of 50 feet above sea level, and are visible from the lagoon. Small dunes up to 13 feet high are also found at the south end of West Island (Plate 9).

(b) Lagoon side

The lagoon shores are formed either of undercut reef limestone or by mangrove communities; the latter are discussed in Section 3(3). The undercut cliffs

of the lagoon shore differ from seaward medium-energy cliffs mainly in their lower total height. The vertical amplitude of the solution notch is approximately the same (6-8 feet), but the vertical cliff above is rarely more than 1.5 feet and in many cases it is so low that it is overtopped by the sea at highest high water. The deep undercutting of the cliffs is striking (Plate 10). The width of the basal erosion platform formed by cliff recession is variable, but may reach 50 yards; it is generally a bare rock platform, with solution grooves normal to the shore, occasional residuals (which because of the calmer waters, especially at the east end of the lagoon, may be of most delicate form), and small patchy beaches at its landward margin. Active recession has isolated many stacks (Plate 11), of which the larger ones are vegetated. Several of these have surface dimensions several times as large as the pillar on which they rest, and it is to these that the term "champignon" (mushroom rock) originally referred. Undercut islands are well seen in both Main and East Channels, along the north shore of South Island, and particularly in West Channels, where the land rim has fragmented to form a series of small islands. Though both Wharton (1878) and Fryer (1911) argued that much of the lagoon cliff recession was caused by the mechanical and chemical action of mangrove roots, it is more likely that the undercuts are formed by a combination of physicochemical and biogenic (algal and molluscan) activities. Fryer, however, is clearly correct when he states that the lagoon is actively enlarging at the expense of the land.

Much of the lagoon floor is covered with a thin layer of calcium carbonate mud, overlying an irregular rock floor. Shoals of calcium carbonate sand are exposed during low tides. Living corals are confined to the neighbourhood of West and East Channels, but are scarce elsewhere. Air photographs indicate a watershed between the Main and East Channels, as shown by bottom sediment patterns, 4-5 miles west of the latter.

2. Surface Morphology

(a) General features

The main features of the surface geomorphology of Aldabra have been described by Fryer (1911, 401-405), when the local terms "champignon" and "platin" entered the reef literature. The distinction between the two tends to oversimplify the morphological variations. It is clear that two distinct sets of factors, lithology and process, have influenced the development of the present landforms. Champignon is used for deeply pitted and irregular solution-fretted reefrock, and platin for smooth surfaced, pavement-like cemented limestones. Champignon (Figure 4) occupies the greater part of West, Polymnie and Middle Islands, together with most of South Island from West Channels to 1.5 miles east of Dune Jean Louis. It forms a zone several hundred yards wide round the eastern end of South Island, and near East Channel occupies the whole width of the island. Platin, apart from small areas near the settlement on West Island, occupies the greater part of the eastern end of South Island, from Takamaka towards East Channel. It covers a total area of 14 square miles, 28 per cent of the dry land area (excluding mangrove), or one quarter of the total land area. Champignon forms the higher parts of the atoll rim, generally rising to 10-15 feet above

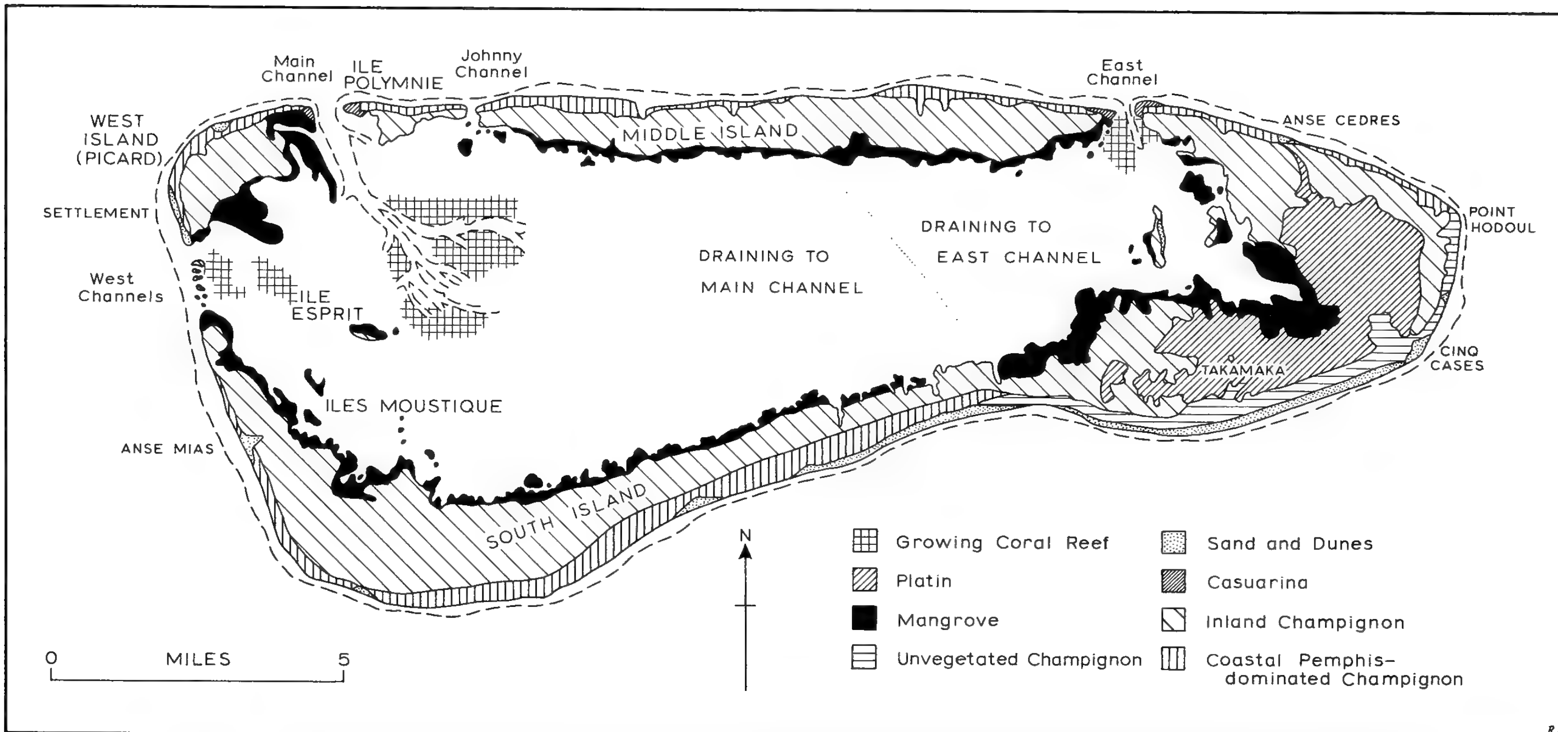


FIG. 4 MAJOR HABITATS OF ALDABRA ATOLL

Figure 4.--Major Habitats of Aldabra Atoll

mean sea level; the platin is lower, and ranges from approximately 3-10 feet above mean sea level.

(b) Surface solution features

The nature of champignon dissection varies considerably in scale and origin, though no descriptive terminology exists for the resulting forms. The largest erosional features are tidal solution holes excavated to intertidal levels, tens or occasionally hundreds of yards in extent, and which are clearly expanding by solutional recession and undercutting of the marginal cliffs, exactly as on protected lagoon shores. These holes may dry completely at low water, but flood rapidly on the rising tide. They are normally close to the sea or the lagoon, but we have no information on tidal lag. The mollusc fauna is marine, and the floors of the holes are covered with soft sediment. Good examples were seen south-east of the West Island settlement at Basin Cabris, and west of Point Hodoul. In the latter (Plate 21), several small residuals have been isolated in the middle of the hole by the rapid recession of the margins.

Normal champignon sinkholes are on a smaller scale. They are vertical clefts, often in the centre of wider surface depressions, and in many cases become wider with depth. Their mouths are usually less than 15 feet wide, and their depth appears to be a function of the height of the land surface above sea level. The deepest seen on South Island, in areas of high champignon perhaps 15 feet above sea level, were 12-15 feet deep. Though it was the dry season, most had standing water, with a brackish-water molluscan fauna. The dry sinkholes have a bottom full of yellow-brown silt and clayey sediment. There is no evidence of the solutional undercutting characteristic of marine tidal solution, but the walls are vertically furrowed by freshwater solution.

The third level of dissection in champignon is that of pinnacle and pothole[1] formation on the surface, which gives champignon its distinctiveness. The most extreme and intricate pinnacle formation is found in the salt-spray zone on top of seaward cliffs, where holes and pinnacles are angled slightly seawards. The bottoms of the holes are round in plan, and flat, and at lower levels contain salt water. They are similar to salt-spray solution features described, for example, from Puerto Rico by Kaye (1959), and seen on many of the Solomon Islands, particularly on New Georgia. Away from the salt-spray zone, in areas where surface solution is by fresh water, the dissection is less extreme. In the most dissected salt-spray champignon the holes and pinnacles may have a vertical amplitude of more than 1 foot, with comparable diameters; in the freshwater zone this is infrequent, and the surface dissection grades towards a broken scoriaceous or honeycomb character. Champignon is generally devoid of surface soil, except for thin sandy deposits on the floors of some potholes (Plate 13).

Solutional processes on platin operate on two levels. Though gradients are gentle, the platin has a local relief of up to 6 feet, and the surface consists of many local surface-drainage basins centred on solution pans. Many of these

---

[1] The term 'pothole' is usually used for mechanically-scoured features formed by fluvial action (Baulig 1956, 106); the term as used here is synonymous with 'solution cup' and is used descriptively (Baulig 1956, 61-62).

dry out during the dry season (Plate 27), and even the largest are considerably reduced in size (Plate 24). Flamingo Pool, the largest, has a dry season diameter of about 200 yards. All are freshwater, as shown by their molluscan and crustacean microfauna; and it is clear that during the wet season these pools expand, some perhaps coalesce, and large areas of platin are covered by up to 2 feet of water. This is demonstrated by the solutional undercutting of limestone residuals between the pools, and by the distribution of shells of the freshwater mollusc Bulinus, found 1.5-2 feet above the general platin surface, lodged on limestone residuals. The gross topography of surface dimpling associated with these pools is probably solutional, though solution may be a discontinuous process. Several pools, during the dry season, are surrounded by ramps of mammillate limestone, samples of which show depositional layering. Clearly solution during the rains is followed by marginal deposition as pools dry out. Most of the surface drainage is local and unintegrated; only near Cinq Cases is there any sign of a short, semi-permanent drainage line leading to a central sink (Plate 23), though such features may be more widespread during the wet season.

The second platin solution process is small-scale and local. In areas of flat surface, lacking drainage systems, rainwater may stand for days after falling. By processes not yet studied, these rainwater pools are able to etch the limestone surface by solution, and gradually become incised, and bounded by clifflets showing pronounced basal solution-notching (Plate 16). Most of these incised pools are not more than 6 inches deep, though the deepest was more than 1 foot, and most are a few yards in maximum dimension. The floors are absolutely smooth, thinly-coated with a film of cream-coloured sediment, and strongly contrasting with the rougher grey surface of the interpool areas. The striking flatness of the platin results partly from the final smoothing by this process of the dimpled surface formed by the main solution pans (Plate 15).

3. Origin of Aldabra Landforms

Fryer (1911, 405-407) distinguished three main rock-types at Aldabra: the peripheral elevated reef, exposed in the sea cliffs; the champignon rock, which he termed a metamorphosed limestone; and the platin, which he considered a detrital limestone. He noted the abundance of reef corals in the position of growth in the sea cliffs, and deduced that these constituted an uplifted atoll reef. He drew attention to the freshness of many of the corals: on the surface near the cliffs there are many beautifully preserved Tridacna shells in the position of growth, with open valves, which, with the corals, suggests a relatively recent date for the emergence. The platin rock he considered to be a back-reef deposit, mainly of clastic sediments with molluscs and foraminifera, formed as a reef-flat deposit in the lee of the eastern reef and subsequently uplifted with it. The distinction between the elevated reefrock and the champignon rock was less clear, and Fryer considered the champignon rock to be a phosphatised reefrock. In Fryer's view, the morphology of Aldabra is the result of relatively minor solutional modification of a reef topography formed before the elevation of the atoll, and this interpretation superseded Voeltzkow's (1902a) thesis, influenced by Murray's theory of atoll formation, which laid stress on the uplift of a bank of deeper-water foraminifera coated by corals.

Fryer's interpretation neglects several geomorphic features which indicate a more complex history, as Fryer himself realised in his account of Ile Esprit (1911, 407-408). The platin surface of South Island is not simply a slightly modified depositional surface, but has undergone considerable vertical erosion. Following uplift of both platin and champignon, vertical solution holes are formed, and fine brown residual sediment is washed into them and ultimately lithifies. This brown pipe-limestone is much more resistant to solutional erosion than the surrounding white limestone, especially in the platin, and it weathers out to form stacks or pillars on retreating cliffy coasts, where it is morphologically identical with similar pipe-limestones studied in the British Solomon Islands. The pipe-limestones are also exposed by vertical erosion, and the flat surface of the platin is interrupted by massive irregular blocks of brown pipe-limestone 3-6 feet high, and in some cases 6-9 feet in diameter (Plates 18 and 19). The surfaces of the residuals are furrowed by solution lapies, and near the freshwater pools they may be solutionally undercut. With the open vegetation, the resemblance of the pillars to termite mounds gives the platin landscape a distinctly African savanna landscape appearance.

The residuals show that in spite of the flatness of the platin surface, the main platin surface is erosional, and the original surface must have been at least 6 feet higher and probably more. Over much of the platin, this would bring it closer to the level of the peripheral champignon. The residuals themselves must be distinguished from isolated patches of champignon within the platin area: these may stand up to 5 feet above the general platin surface, and have a typically scoriaceous surface. They are interpreted as patch reefs on the former reef flat, and demonstrate the original topography was itself irregular. Since the solution of these isolated champignon patches is purely by fresh water, their dissection is less extreme than on the coastal champignon.

The character of the platin surface is highly variable, with facies changes in the back-reef deposits. Generally the surface is strongly lithified, and weathering is taking place by spalling or exfoliation of large but thin slabs of rock, which ring musically when walked over (Plates 15 and 17). This process, which is more characteristic of igneous rocks, has also been observed at Rangiroa Atoll, Tuamotu Archipelago (Stoddart, in press), and in the northern Marshall Islands (F. R. Fosberg, personal communication), but the processes causing it are not fully understood. At another location on the platin, where the superficial deposits contained marine mollusca, it was found that these were weathering out of a loosely cemented coquina. It should ultimately be possible to map these facies zones in the back-reef area.

If the hypothesis of at least six feet of vertical downwearing is accepted, certain difficulties remain. The flatness of the platin surface and its level above mean sea-level are problems. It is also implied that in the past solutional downwearing has proceeded rapidly on platin, though at present these processes are slow, and in places deposition is taking place; whereas on the champignon, which is the area of deepest and most intricate dissection, it is argued that least downwearing has occurred. Complete explanation of these anomalies is not yet possible. In the case of the platin, we need to know the relationship between its near-equilibrium surface and tidal levels. In the case of the champignon, it is known that fresh rock exposures are less resistant than older ones, and it may be suggested that the most intricate dissection of champignon takes place

rapidly after exposure, and that case-hardening then decreases the rate of solution and protects the surface.

Fryer himself emphasised the anomalous character of Ile Esprit, in the lagoon. Here a complex topography of pinnacles and depressions with a vertical relief of up to 18 feet resembles in miniature a tropical Kegelkarst (Plate 14). The central part of the island is formed by a relatively undissected ridge rising to more than 30 feet. The island is composed of shelly limestone overlain by cemented limesands, with vitreous brown cavity fills. Fryer interpreted the whole as a lithified homologue of the soft sediments in the large tidal solution basin on West Island, the implication being that the reefrock surrounding these pan sediments, to a height equal to at least that of the highest part of the island (30 feet), has been eroded away. Comparison of the shell limestone and limesands, with the vitreous cavity fill, which Baker (1963, 109) found to have a phosphate content of 35-40 per cent, and the normal pipe-limestone of other parts of the atoll does not convince that they have a similar origin. The height of the Esprit ridge, approximately 15 feet higher than any other solid rock on the atoll, requires explanation. It is possible that the original uplift of the atoll was not less than 30 feet, and that Esprit is the last remnant of a widespread lagoon fill; but in this case the horizontal bevelling of the marginal cliff tops at about 15 feet presents an additional problem.

While in detail the morphology of the raised reefs is complex, therefore, and their history incompletely known, the two major controls are seen to be lithology and type of solution. The elevated coral limestones, with their coarse honeycombed structure and high permeability, lend themselves to deep and intricate dissection and the formation of sinkholes which may coalesce to form larger features. The fact that champignon dissection is most extreme near the sea indicates that salt spray is a powerful agent of solution. In the finer-grained, less permeable, back-reef deposits forming the platin, the original honeycomb structure is absent, and the solutional depressions formed by fresh water are broad, shallow features. Where patch reefs formerly existed on the platin, however, a modified form of champignon surface is formed, with freshwater solution giving a scoriaceous surface rather than deep honeycombing.

The land area is actively decreasing, by retreat of both the seaward and lagoon cliffs, forming wider seaward intertidal platforms and a larger lagoon. By measuring the rate of solution retreat of the cliffs, it should be possible to calculate the rate of formation of the seaward intertidal platform. Assuming (a) a mean width of 200 yards for the platform, and (b) a period of 5,000 years since sea-level reached its present level in the Holocene, suggests a rate of seaward cliff retreat of 1 yard in 25 years, if the platform is formed by cliff retreat wholly in the Post-glacial. This rate is probably excessive in view of the measured rates of notch formation, averaging 1 mm per annum, in other parts of the world: Aldabra would form an excellent location for field studies of limestone solution rates.

3. FLORA AND VEGETATION

The first botanical collecting at Aldabra was that of Abbott in 1892 (Baker 1894). Voeltzkow's collections made in 1895 were studied by Schinz (1897; also Voeltzkow 1902b). Further collections were made and reported by Dupont

(1907, 34-41, and later), by which time at least 100 species of flowering plants had been recorded. Fryer's account (1911, 414-416) includes the first detailed ecological notes, and his collections, together with those of W. Fox, who visited Aldabra in 1916, were worked up, with all the earlier material, in W. B. Hemsley's "Flora of Aldabra" (1919; also Hemsley 1916, 1917), which remains the standard reference. Christensen (1912) noted a single pteridophyte; and Vesey-FitzGerald (1942) added useful ecological notes on the vegetation. A further collection of 55 numbers, including 45 species, was made in 1966 and has been identified at Kew.

The flora is thus relatively well known. Hemsley's flora contains 173 species of flowering plants recorded from Aldabra, together with a number of common atoll species recorded from nearby islands, which might also be expected to occur at Aldabra, but which had not then been collected there; a few additional records were obtained in 1966. Of this total he considered 68 to be indigenous, in the sense of not being artificially introduced by man; and this compares with figures for the indigenous floras of the Chagos Archipelago of 49 species and the Maldive Islands of 87 species. Of the 68 species, Hemsely considered 18 to be endemic to Aldabra itself (forming about 10 per cent of the total flora), and 13 to be confined to the Aldabra group (Assumption, Cosmoledo, Astove, St Pierre, Gloriosa). Of the rest, 18 species are Madagascan, and 11 are East African; and the flora is thus clearly related to that of the nearby continental areas. Table 2 lists the strict endemics and Table 3 the group endemics recorded by Hemsely (1919); no attempt has been made to revise nomenclature.

Table 2. Endemic species in the Aldabra flora

Capparidaceae
- *Maerua dupontii* Hemsl.

Tiliaceae
- *Grewia aldabrensis* Baker
- *Grewia salicifolia* Schinz

Erythroxylaceae
- *Erythroxylon acranthum* Hemsl.

Ochnaceae
- *Ochna fryeri* Hemsl.

Leguminosae - Papilionatae
- *Tephrosia aldabrensis* J. R. Drum. and Hemsl.

Leguminosae - Caesalpinioideae
- *Cassia aldabrensis* Hemsl.

Leguminosae - Mimosoideae
- *Pithecelobium ambiguum* Hemsl.

Rubiaceae
- *Oldenlandia* sp. n. ? Hemsl.
- *Tricalysia cuneifolia* Baker
- *Pavetta supra-axillaris* Hemsl.

Compositae
- *Vernonia aldabrensis* Hemsl.

Plumbaginaceae
- *Plumbago parvifolia* Hemsl.

Oleaceae
- *Jasminum aldabrense* Hemsl.

Amarantaceae
- *Apterantha oligomeroides* C. H. Wright

Loranthaceae
- *Loranthus aldabrensis* Turrill

Euphorbiaceae
- *Phyllanthus cheloniphorbe* Hutch.
- *Acalypha fryeri* Hutch.

Table 3. Group endemics in the Aldabra flora

Capparidaceae Cleome strigosa Oliv.	Verbenaceae Nesogenes dupontii Hemsl. Clerodendron minutiflorum Baker
Icacinaceae Apodytes mauritiana Planch.	Euphorbiaceae Euphorbia abbottii Baker Acalypha claoxyloides Hutch.
Plumbaginaceae Plumbago aphylla Bojer	
Asclepiadaceae Secamone fryeri Hemsl.	Moraceae Ficus aldabrensis Baker
Solanaceae Solanum aldabrense C. H. Wright	Dioscoreaceae Dioscorea nesiotis Hemsl.
Acanthaceae Hypoestes aldabrensis Baker	Liliaceae Asparagus umbellulatus Sieber

Less is known, however, of the distribution and ecology of the vegetation, apart from the broad outlines sketched by Fryer (1911), followed by Hemsley (1919), and amplified by Vesey-FitzGerald (1942). Vesey-FitzGerald distinguishes four vegetation types:

1. Mixed scrub (Fryer's open bush);
2. Pemphis thicket (Fryer's Pemphis bush);
3. Mangrove communities; and
4. Psammophilous associations (Fryer's shore zone);

to which a further category may be added,

5. Man-induced vegetation.

These vegetation types are closely associated with the morphological zones defined in Section 2(2). Mixed Scrub is found on platin, Pemphis thicket on champignon, psammophilous associations on beaches, dunes and coastal cliffs, and the mangrove communities on the lagoon margins. The species-composition of each type is known only imperfectly, however, and there is little information on internal variation within the types. Analysis is made more difficult by the lack of activity during the dry season, when many trees in the Mixed Scrub lose their leaves, and few plants are in flower anywhere on the atoll. This was the situation during the 1966 expedition. By contrast, flowering is reported to be rapid and widespread at the onset of the rainy season, in January, when more collecting needs to be done.

1. Mixed Scrub

The Mixed Scrub is especially variable, both in floristic composition and in density. At the east end of South Island, the scrub is most dense on isolated patches of scoriaceous champignon, and more open on the platin, particularly near the freshwater pools (Plates 15-18). A number of species, including Euphorbia abbottii and Thespesia populnea, appear to vary in frequency in different areas, but the most conspicuous segregation is that of the screwpine, Pandanus vandermeeschii, at pool margins (Plate 24). Though most of the trees in the Mixed Scrub are slender and shrublike, and less than 15 feet tall, the denser scrub is very difficult to penetrate and is devoid of directional indicators: when it is possible to climb a low tree, the pandans are excellent indicators of the location of freshwater pools. In terms of normal atoll floras, it is the Mixed Scrub which has the most unusual and African aspect, and many expected atoll species are absent, or, as in the case of the leafless vine Cassytha filiformis, rare. Taller trees are found only occasionally, and the massive Ficus and Calophyllum at the Takamaka pool are best known (Plate 22). On the more open platin the orange-tinged sedge Fimbristylis spathacea forms an irregular tortoise-cropped turf (Plate 16), with small brittle rosettes of Eragrostis sp. on bare rock in between. In addition to the sedges, the tortoises also crop the lower leaves of shrubs up to a maximum height of about 4 feet. Other grasses and sedges growing beneath the trees include Eragrostis riparia, Cyperus obtusiflorus, Kyllinga nemoralis, and Fimbristylis ferruginea.

Floristically the area of Mixed Scrub on West Island is similar to that on South Island, though probably with more introductions from the settlement. Plumbago aphylla and the vine Abrus precatorius, with its distinctive black and red seeds, were collected here in 1966, and leafless Euphorbia abbottii trees were common.

Acrostichum aureum, the only recorded fern, is widespread in the deeper clefts and sinkholes on South Island (Plate 23), both in the Mixed Scrub and in Pemphis thicket.

It is likely that when the Mixed Scrub is better known it will be considerably subdivided, and differentiated in terms of substrate and location.

2. Pemphis Thicket

Pemphis Thicket is named after its dominant, Pemphis acidula, a species widespread on uplifted reefs in the Indo-Pacific, but here extraordinarily luxuriant (though absent in the Seychelles). The thicket has a maximum height of about 15 feet, and though the trunks and branches of the Pemphis are slender they are extremely tough and grow in such profusion that penetration is difficult. Because of its association with the soil-less champignon, Pemphis Thicket occurs to seaward of the Mixed Scrub on South Island, and to a lesser extent along the lagoon shore. It covers most of the exposed rock areas of the other main islands, except for an area of Mixed Scrub at the south end of West Island, and clumps of Pemphis are found even on minute reefrock islets in the lagoon. On the northern side of the atoll, Pemphis is normally the first shrub met with at the cliff-top (Plate 2), and largely replaces the Scaevola-Tournefortia zone normally found in sandier habitats. Inland its dominance is reduced,

and Pemphis is found with many of the Mixed Scrub species, forming a thicket that is much denser than the Mixed Scrub itself, and in places a woodland in which Pemphis itself is rare. Mystroxylon aethiopicum and Ficus sp. are common in such areas on South Island, and Dracaena reflexa was collected in dense mixed Pemphis thicket on West Island near Main Channel. In these transitional areas, Pemphis is most dense round the margins of the larger sinkholes, where it may be almost impenetrable, except with extreme labour. Smaller flowering plants in potholes include the thorny Capparis galatea, with a conspicuous white flower, and wisps of Oldenlandia sp. Most of the rock surface beneath the shrubs is bare, with sparse and scattered clumps of Mariscus ligularis and Eragrostis riparia.

The flatness of the ground combines with the uniform height (10-15 feet) of the vegetation to make travelling except with a compass very difficult; and Wharton (1883, 77) gives a graphic account of the difficulty of traversing Pemphis-covered champignon when he states that "a walk in Aldabra is the most aggravating and slowest piece of locomotion I have ever engaged in: and nothing short of the patience, perseverance, and general disregard of time of the tortoise tribe can make it an agreeable residence. Some of my Negro sailors were sent into the bush to hunt for tortoises, and after three days' search brought back one . . .; but they returned nearly as guiltless of artificial clothing as their captive."

3. Mangrove Communities

The mangrove communities have been discussed by Fryer and Vesey-FitzGerald. Both agree on the zonation of the genera: Bruguiera and Ceriops at the head of creeks; Rhizophora (R. mucronata) on deeper mud in the creeks themselves; Avicennia (A. marina) on open lagoon flats subject to tidal flooding; and Lumnitzera in isolated inland depressions. It has been argued (Wharton 1883; Fryer 1911, 403, 409) that the lagoon mangroves are instrumental in eroding the lagoon margins, both by the mechanical effects of root growth in crevices, and by the chemical activity of mangrove mud. It can, however, be seen that the undercut lagoon margins and creek systems are morphologically similar whether mangroves are present or absent. Wherever mangroves were seen growing in intimate association with eroding cliff forms, there was no evidence of mechanical activity; rather the trees appeared to be growing in pre-existing holes. Fine carbonate sediment is certainly being formed, however, and the processes need examination. The main mangrove area surrounds the Bras Takamaka, at the southeast end of the lagoon, where it totals more than 3 sq. miles. Large areas also exist on West Island (0.6 sq. miles), and at the west end of South Island, opposite Iles Moustique (1 sq. mile). Many of the small lagoon islands have areas of mangrove. The mangroves seen in Bras Takamaka are low and open. Taller trees, up to 40 feet high, were seen on the lagoon side of Middle Island, where the mangroves perch precariously on the edges of limestone islands intersected by deep tidal channels. Tall mature mangroves were described on West Island by Dupont (1907), but there was no opportunity to see these in 1966. Half a century of exploitation for timber and bark must have severely modified the mangroves of West and nearby South Island, but no investigation could be made of this in 1966. Further damage is caused from time

to time by cyclones, and defoliation is described by Fryer (1908-9). The mangroves play an important part in the ecology of sea and shore birds at Aldabra.

4. Psammophilous Communities

Fryer's Shore Zone Vegetation, in which most of the plants are common pantropical or Indo-Pacific strand species, may be further subdivided in terms of habitat. Vesey-FitzGerald (1942) distinguishes a spray-zone community, dune scrub, and a herb-mat community. The spray-zone community itself varies with aspect. On the windward side of the atoll, from Takamaka to Point Hodoul, a narrow belt of blown sand at the cliff top is succeeded inland by a zone several hundred yards wide of bare rugged champignon. At the seaward edge of the Mixed Scrub community, most of the larger shrubs and trees are gnarled and dead, leaning away from the wind (Plate 20), and even Acrostichum, the leather fern, nestling in crevices, is shrivelled and brown. The living vegetation in this maximum exposure area consists of dwarf flowering plants (Sida parviflora, Portulaca quadrifida, Evolvulus alsinoides, Hypoestes sp., Lagrezia madagascariensis, Oldenlandia sieberi) and sedges and grasses (Eragrostis sp., Dactyloctenium pilosum) sheltered from the wind in potholes and crevices, with thorn bushes such as Solanum aldabrense and Capparis galatea in the larger holes. Many of the common strand species, such as Tournefortia, Scaevola, Suriana and Ipomoea are absent from this habitat.

In more protected conditions, from Point Hodoul towards Anse Cedres, the Mixed Scrub and Pemphis communities approach within 30 yards of the cliff-top, and form a hedge of Pandanus with occasional clumps of Scaevola sericea (Plate 1). The zone between the Pandanus and the cliff edge, intermittently carpeted with sand, is colonised by a sparse community of coarse tussock grass (Sclerodactylon microstachyum) with scattered low Scaevola and occasional Tournefortia. From Anse Cèdres westwards, the vegetation approaches within a few feet of the cliff edge and is dominated by Pemphis, with occasional Guettarda speciosa, Scaevola sericea and Tournefortia argentea; a distinct spray-zone community can hardly be said to exist.

No observations have been made on the south and west coasts of South Island. Most of the coast is presumably covered with dune scrub, with tall Sclerodactylon macrostachyum, low carpets of a Paspalum-like grass, and Scaevola and dwarf Guettarda, according to Vesey-FitzGerald (1942). A modified dune scrub is also found at the south end of West Island (Plate 9), where it is interesting that some of the dwarf flowering plants, such as Sida parviflora, are the same as those inhabiting potholes in the most exposed spray zone of the windward coast. Tall shrubs on these dunes include Azima tetracantha and Acalypha claoxyloides, together with the grasses Dactyloctenium pilosum, D. aegyptium, and Eragrostis riparia, the attractive blue-flowered Cleome strigosa, and Scaevola. Low fresh sand spits below the dunes are being colonised by the sedge Cyperus maritimus and seedlings of Scaevola and Tournefortia (Plate 12). The low dunes between Takamaka and Point Hodoul are occupied only by a turf formed by a Paspalum-like grass, and bunch-grasses (Plates 6, 7 and 8).

Vesey-FitzGerald adds a third community, the herb-mat community, found in the western Indian Ocean islands particularly beneath dense bird colonies, but this does not seem to have an Aldabra counterpart.

5. Man-induced Vegetation

To the vegetation types distinguished by Fryer and Vesey-FitzGerald is added the category of man-induced vegetation. In addition to the 173 species listed in his flora, Hemsley (1919) refers to a number of introduced economic species reported from Aldabra, including

Amaranthus tristis
Amaranthus gangeticus
Brassica nigra
Carica papaya
Gossypium barbadense
Ocimum canum
Ricinus communis
Lochnera rosea
Cocos nucifera.

Further species were added to this list in 1966.

Man-induced vegetation is of three main types: coconut plantation, Casuarina thicket and woodland, and village vegetation. Coconuts are only found in small clumps at the settlement on West Island (Plates 38 and 39); intermingled with other species to form a coconut thicket on Ile Michel; and reportedly also at some of the pocket beaches at the west end of South Island (e.g. Anse Mais). Clumps of tall Casuarina are found at Anse Cèdres (Plate 37), on both sides of East Channel, at Ile Michel, and on both sides of Main Channel, as well as at the settlement on West Island (Plate 40). They vary from open woodland with no undergrowth to dense thickets of broken trunks and saplings, though much of this damage observed in 1966 had resulted from a recent cyclone. Needles carpet the ground, obscuring the irregularities of the champignon and in places making walking dangerous, and apart from rare Scaevola and Tournefortia seedlings there is no ground vegetation. At the landward margin there is some invasion by tall spindly Scaevola and other plants, and the red flowers of the aloe-like Lomatophyllum borbonicum are in places conspicuous.

The introduction of coconuts and the spread of Casuarina date from the end of the nineteenth century. H.M.S. Fawn planted fifty coconuts at Ile Michel in 1878, together with Casuarina (Findlay 1882, 550). Active planting of coconuts by lessees began about 1880, and for some time was made a condition of the lease. Dupont in 1906 found about 1000 coconuts at the West Island settlement up to 25 years old, and the small pocket beaches at the west end of South Island were also planted at this time (Dupont 1907, 21). It is likely that the main Casuarina groves, however, already existed at the time of the Fawn survey. It is said that James Spurs, when lessee, went so far as to dynamite holes in the champignon in which to plant nuts, in his efforts to establish thriving coconut plantations (Anon. 1920).

Village vegetation includes cultivated plants, such as cotton and sisal, and cultivated trees, together with common pantropic weeds and cultivated decorative plants. Agave and Gossypium grow in the settlement itself, with thickets of Caesalpinia bonduc and taller trees of Moringa pterygosperma. Fruitbats were

seen in 1966 apparently feeding on the flower buds of Agave during the day time. There are also early reports of the cultivation of maize and tobacco. The common weed Stachytarpheta indica is found only at the West Island settlement, and near the abandoned fishing hut on the west side of East Channel. The most common decorative flowering plant, planted round most of the houses in the settlement, is Catharanthus rosea, in both white and pink varieties. Clearly human settlements are acting as foci for the introduction of alien species, though these have not yet made much progress against the native vegetation and are still sharply circumscribed.

The role of man and animals in controlling native vegetation needs study. Man has harvested mangrove for timber and bark since the 1880s (Dupont 1907, 23-24), but on a small scale. Tortoises and goats crop the lower vegetation, including grasses, sedges, and the lower leaves of trees and shrubs, particularly in the more open Mixed Scrub. Birds must have a considerable direct effect on leaves and branches, and an indirect effect on soils and the phosphorus cycle, particularly in the large Middle Island breeding colonies, and this too needs further study.

4. TERRESTRIAL FAUNA

In common with most island faunas, that of Aldabra is notably disharmonic, with many groups unrepresented, and with a degree of probable endemism in those which are; and it is notable for the survival there of forms unsuited to competition with introduced species, in which class the land tortoise is the outstanding example. It is difficult to discuss the biogeography of the land fauna at the present time: in many groups the taxonomy itself has been inadequately worked out; many groups at Aldabra have been collected only casually or not at all; and for those which are better known, particularly the insects and the land birds, so little work has been done in neighbouring areas that the biogeographic relationships and degree of endemism are uncertain.

1. Mammals

Mammals are represented in the native land fauna only by fruit-eating and insectivorous bats, which are also found in both the Seychelles and the Mascarene Islands. The fruit bat was collected by Abbott in 1892, and was described as an endemic species, Pteropus aldabrensis, by True (1893). This beautiful animal was seen during the day in 1966 on the branches of large Ficus trees at Takamaka Pool, though Fryer (1911, 416) states that "it never forms large gatherings on a tree during the daytime." The insectivorous bats are more widely distributed. Fryer names them as Taphozous mauritianus and Triaenops furcula, and Miller (1902) names one as Nyctinomus pusillus. The insectivorous bats are seen at dusk at the West Island settlement, and in the Casuarina groves at East Channel, where a specimen taken in 1966 has been identified as Tadarida pumila (= Nyctinomus pusillus).

2. Birds

The land birds, of which there are sixteen known resident species, are most numerous in the Mixed Scrub on the platin, and in Casuarina and coconut groves.

Benson (1967) considers that only one, the Drongo Dicrurus aldabranus, is a full species endemic to Aldabra, but at the same time only two of the native Aldabra land birds cannot be distinguished from other members of the same species in nearby areas (the Grey Heron Ardea cinerea cinerea and the Barn Owl Tyto alba affinis). Endemic subspecies are the Sacred Ibis Threskiornis aethiopica abbotti, the rail Dryolimnas cuvieri aldabranus, the nightjar Caprimulgus madagascariensis aldabrensis, and the fody Foudia eminentissima aldabrana, the last of which commonly occurs at the West Island settlement and in Casuarina woodland elsewhere. Good subspecies found on Aldabra and also on nearby reef islands are the little Green Heron Butorides striatus crawfordi, the Madagascar Turtledove Streptopelia picturata coppingeri, and the Souimanga Sunbird Nectarinia sovimanga aldabrensis. Aldabra also has less distinct forms of the kestrel Falco newtoni aldabranus, the Comoro Blue Pigeon Alectroenas sganzini minor, the Madagascar Coucal Centropus toulou insularis, the Madagascar Bulbul Hypsipetes madagascariensis rostratus, and the Madagascar White-eye Zosterops maderaspatana aldabrensis. Benson finds the land avifauna to be mainly of Madagascan origin, and suggests colonisation either via the Comoros or via Gloriosa and the islands to the east of Aldabra. For detailed consideration of the native land birds, and also of recent arrivals such as the Pied Crow Corvus albus, see the accompanying papers by Benson (1967) and Gaymer (1967): three species only are considered further here, on account of their susceptibility to human interference.

The White-throated Rail Dryolimnas cuvieri aldabranus (Gunther 1879) is almost flightless. Rails, many of them flightless, are found on islands throughout the world, though many of the insular populations have recently become extinct following the introduction of predators and increased human activity. Thus the rails of Laysan and Wake Island in the Pacific have both recently become extinct. Fryer (1911, 418) reported that the Aldabra rail "is generally distributed over the atoll, though it is scarce on Picard (West Island), and has generally been exterminated in the neighbourhood of Takamaka by the cats". Abbott (1893, 762) feared that the rail would soon be exterminated, "as their arch enemy, the cat, has already exterminated them from Grande Terre (South Island), and must sooner or later reach the other small islands of the group, where the rails as yet abound in great numbers". Voeltzkow (1897, 63) had found them plentiful and extremely tame. They have been recorded from Ile Esprit by Fryer (1911, 418) and from Ile Michel (Anon. 1920, Ch. 8, 9; Vesey-FitzGerald 1940, 487). Rails now exist on Middle Island, where they were seen in 1966, and on Polymnie (Bourne 1966), but they have disappeared from West Island. Abbott (in Ridgway 1895, 528-529) gives an account of their behaviour. Related birds formerly existed on Assumption, Cosmoledo and Astove, but have all become extinct in this century, and the flightless rail of Aldabra is now the last of the flightless birds of the Indian Ocean islands, a series which once included the dodo and the solitaire (Lorenz 1908, Hutchinson 1953).

The Sacred Ibis Threskiornis aethiopica abbotti, is conspicuous on South Island, particularly round the major freshwater pools, each of which has one or two birds (Plates 28 and 32, and illustrations in Nicoll 1908). At Takamaka it is still extremely inquisitive and has to be kept away from baggage, as described by Nicoll (1908, 121), but elsewhere it is less approachable. It is rare at the west end of the atoll, and was absent from West Island near the

settlement fifty years ago (Nicoll 1908, 119). Fryer (1911, 417) reported it on Ile Michel, and also described the destruction of eggs by the birds in a nesting colony on South Island (1911, 417-418). Gaymer found the sacred Ibis nesting at Takamaka (Plate 33). Because of its inquisitiveness it would undoubtedly suffer if the human population of Aldabra increased.

Another species in considerable danger is the flamingo, Phoenicopterus ruber roseus, which is not yet definitely known to breed, and which Benson (1967) does not consider to be distinct. Abbott in 1892 found a population of 500-1000 birds, in flocks of 20-60 individuals, on the south and east shores of the lagoon (Ridgway 1895, 529). Dupont (1907, 21, 23) reported numerous flocks of several hundred birds along the south side of the atoll, and he and Fryer (1911, 419) describe their flight and cries. More recently, Travis (1959, 202) noted "several small flocks" on the north side of the atoll, but the Bristol Seychelles Expedition suggested that there may be only 50 left, and that the survivors breed in the Bras Takamaka (Plate 36). It was not seen in 1966. Fryer collected the bird louse Esthiopterum subsignatum from this species in 1908-9 (Scott 1914).

Sea and other shore birds are numerous (Vesey-FitzGerald 1941; Benson 1967), and include both breeding and migrant species. Frigate birds (Fregata minor aldabrensis and F. ariel iredalei) and Red-footed Boobies (Sula sula rubripes) nest in great numbers in the mangroves of Middle Island, where the former are concentrated towards East Channel and the latter near Johnny Channel, though the nests of both species are intermingled. Fryer (1911, 419) reported a nesting colony of frigates on West Island which has now disappeared. As is usual with this species the frigates parasitise the boobies, spending the day soaring on air currents to heights of a few thousand feet over the windward end of the atoll, awaiting the return of the boobies with food. Though no adequate observations could be made of these vast colonies in 1966, it appeared that the number of frigates greatly exceed that of boobies. Several of the large freshwater pools on South Island are frequented by frigates, which dive continuously to drink, scooping up water from the surface in their beaks while still on the wing (Plate 29). Similar diving behaviour of frigates (in this case F. minor palmerstoni) has been reported from a freshwater pool on Canton atoll in the Phoenix Islands (Degener and Gillaspy 1955, 6). It is thought that the Aldabra frigate colonies serve as the major breeding ground for the frigates of the western Indian Ocean, and that a considerable non-breeding population may be scattered over this area (W. R. P. Bourne, personal communication). If an airfield were to be built at Aldabra, the frigates would clearly represent a major aviation hazard, similar to that of the albatrosses at Midway Atoll in the Pacific (Fisher 1966), and any control measures would have to take account of the fact that birds may continue to return to Aldabra to breed for several years.

Red and White-tailed Tropicbirds (Phaethon rubricauda rubricauda, P. lepturus lepturus) were seen nesting on the ground on lagoon islets near East Channel in 1966. Other very common sea birds include the Noddy Anous stolidus pileatus, breeding on lagoon islets (Ridgway 1895, 527), and fairy terns (Gygis alba monte).

Shore and wading birds are especially numerous, particularly in the lagoon at low water. Dimorphic egrets Egretta garzetta dimorpha, in both white and dark phases, are perhaps most striking; together with the Crab Plover Dromas

ardeola, the Turnstone Arenaria interpres interpres, the Sanderling Crocethia alba, the Grey Heron Ardea cinerea cinerea, and the Little Green Heron Butorides striatus crawfordi. For other records, see Benson (1967). The feeding behaviour of the shore birds on the lagoon flats and their dependence on the unstudied invertebrate fauna would repay detailed investigation.

3. Land Reptiles

The land tortoises of Aldabra form, with those of the Galapagos Islands, the only surviving native populations of this giant form. Most of the study of these reptiles has been made on museum specimens, often of doubtful origin, and until recently no work had been carried out on the Aldabra species in the field. On the basis of museum identifications, two species in the Linnean genus Testudo have been segregated for the Aldabra tortoises: Testudo daudinii Dum. and Bibr., on South Island, and T. elephantina Dum. and Bibr., on Middle Island (Rothschild 1915; see also Siebenrock 1904). Günther (1877) distinguished 4 species in the Aldabra group (i.e. Madagascar, Seychelles, and small islands in between) of giant land tortoises, 5 in the Mascarene group, and 6 in the Galapagos Islands; Rothschild (1915) found 7 (plus a possible 2), 8 (plus a possible 2), and 13 (plus a possible 2) in each group respectively. Williams in 1952 placed the Aldabra tortoises in one species, in the genus Testudo, subgenus Asterochelys, species Testudo gigantea Schweigger; with the Galapagos tortoises in the single species Testudo elephantopus (Williams 1952). In their revision of the Order Testudinata, however, Loveridge and Williams (1957, 225) place both the Aldabra and Galapagos tortoises in the genus Geochelone Fitzinger (Family Testudinidae, Subfamily Testudininae). They erect a new subgenus Aldabrachelys Lov. and Will. for the Aldabra tortoise, with the single species gigantea Schweigger (Plate 26). The specific name elephantopus is retained for the Galapagos tortoise, genus Geochelone, subgenus Chelonoidis (Williams 1952). Comparative field studies of South and Middle Island tortoises by the Bristol Seychelles Expedition at Aldabra failed to establish any differences between the supposed species (R. Gaymer, personal communication). Geochelone (Aldabrachelys) gigantea of Aldabra has close relatives in the Pleistocene and Recent of Madagascar and the Indian Ocean islands, and in the Eocene of the Fayum depression, Egypt (Williams 1952; see also Wermuth and Mertens 1961).

Figure 5, based on data in Rothschild (1915), maps the distribution of the Indian Ocean giant tortoises in the early eighteenth century, when, according to Rothschild, they extended from Madagascar to the Seychelles, the Mascarenes, and even to the Chagos Archipelago. In the early eighteenth century, tortoises were abundant on Mauritius, Réunion, and Rodriguez; but during the period 1750-1800 they became extremely rare, and had disappared before 1840. In the eighteenth century they were abundant in the Seychelles and some of the smaller islands of the south-west Indian Ocean; but they had disappared on the main islands and on most of the lesser ones by 1840, surviving only as semi-domestic animals in a few places. We have found confirmatory records in the literature of the former existence of giant tortoises on the small islands of Assumption, Astove, and Cosmoledo, as well as Aldabra; but not for Gloriosa, Farquhar, St Pierre, and Providence, which Rothschild also cites, though

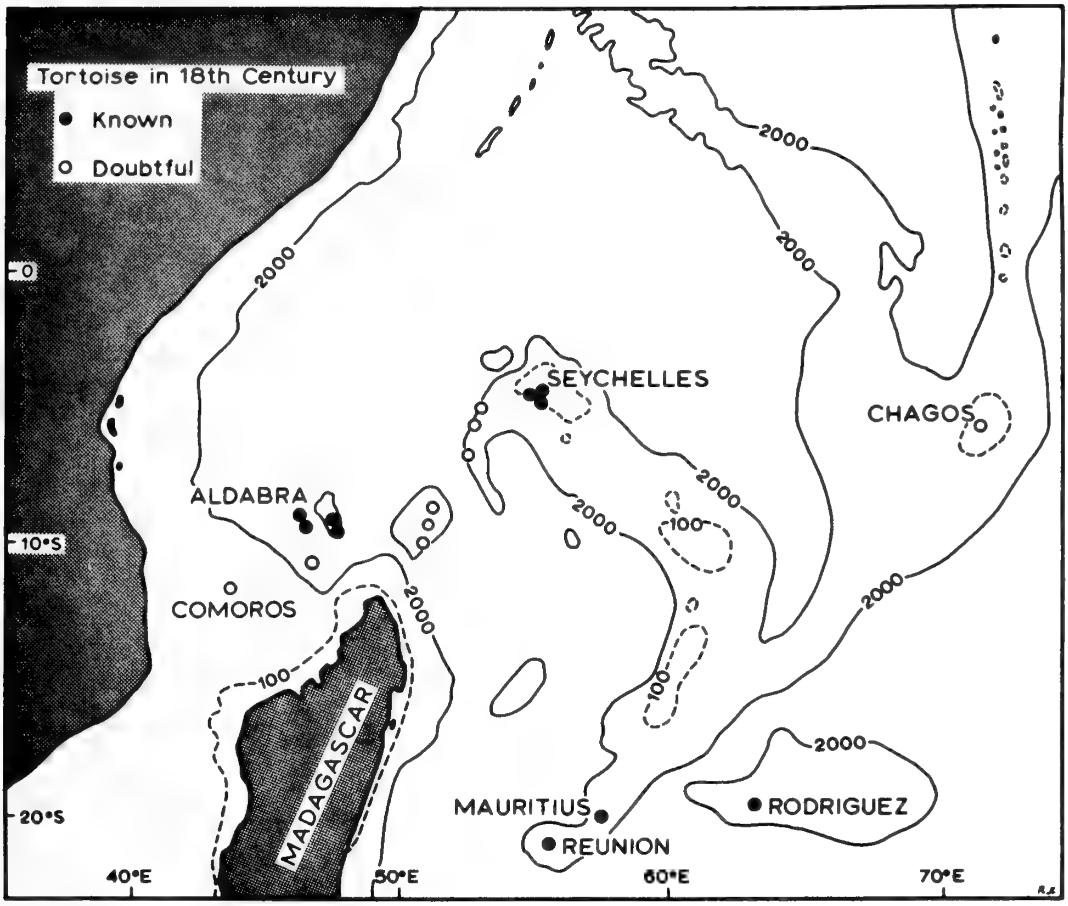


Figure 5.--Distribution of giant land tortoise in the eighteenth century in the Indian Ocean, after Rothschild (1915)

Coppinger in 1882 found seven giant tortoises imported from Aldabra roaming in the woodland on Providence (Coppinger 1883, 234). Nor can we find any record of wild populations in the Chagos Archipelago. These records are therefore marked as doubtful in Figure 5. The case of Providence is an example of the manner in which, as described by Rothschild, domestic herds were recruited from many different islands, and how transfer of wild tortoise took place from one island to another, thus making any detailed study of original variation impossible. Some of the Seychelles domestic tortoises, of unknown provenance, were released, for example, on the north and west islands of Aldabra (Rothschild 1915, 433).

The massive decline in tortoise numbers in the Malagasy Region seems to have resulted from many factors. Direct predation by man for food seems to have been considerable. Sauzier (1893) records exports from the Seychelles and Mauritius of more than 3000 tortoises in 1826, for example, and in 1847 two ships took 1200 tortoises from Aldabra alone (Rothschild 1915, 424; Voeltzkow 1897, 59; Parsons 1962 wrongly states that the animals were turtles). This trade was probably episodic; but with such a long-lived animal

on such small islands it could only have drastic long-term population consequences. Pens built of coral blocks in the nineteenth century, for confining tortoises prior to export, can still be seen in several places on Aldabra, as at Anse Cèdres and Cinq Cases, and are still occasionally used for this purpose. Second, the disturbance of the environment, particularly by the clearing of vegetation and the spread of cultivation, as in the Galapagos, forced the tortoises into more marginal environments, especially in the high islands. By the time that massive guano digging and habitat modification began in the smaller reef islands of the southwest Indian Ocean, the tortoises had generally disappeared: except at Aldabra, where fortunately commercial guano was absent. Third, tortoise numbers were directly affected by the introduction of competitors and animal predators. In the Galapagos, for example, feral pigs attack and kill young tortoises, and rats and dogs also harm the young and may destroy eggs. The introduction of goats, cattle and donkeys in the 1920s led to direct competition for food (Snow 1964), and recent studies have suggested that the Galapagos tortoises will become extinct in this century (Hendrickson 1966, 256). By the time that such introduced species spread to the smaller Indian Ocean islands, however, the tortoise populations had disappared, except at Aldabra, where the rats and feral goats do not seem to be a threat to tortoise survival.

Little is known of tortoise ecology at Aldabra, though a start has been made in field observation by the Bristol Seychelles Expedition. Voeltzkow collected some specimens, and Fryer (1911, 420-421) gives brief notes, but otherwise scientific attention has concentrated on the more accessible Galapagos tortoises. Recent studies have been made by Honegger (in press) in 1964 and by the Bristol Seychelles Expedition 1964-5 (Gaymer, in press). At Aldabra, the tortoises are concentrated on the platin (Plate 27), and are rare on champignon, where because of the irregular terrain and dense vegetation movement is difficult. No reliable estimate is possible of total numbers, though inland from Anse Cèdres, 57 were seen in a traverse of 1 hour in 1966, and 200 in less than 2 hours in a traverse between the lagoon and Takamaka Pool. Prosperi (1957, 201) suggested a total of 80,000 in 1953, and the Bristol Seychelles Expedition, from sample counts in three areas of South Island (at Anse Mais, with 360 tortoise in 3 sq. miles; at Takamaka, with 176 tortoise in 4.5 acres; and in another area of platin, with 8 tortoise in 19,200 sq. yards), and extrapolation on the basis of areas of platin and champignon shown on published maps, suggest totals of 30,000 tortoise on South Island, 3,370 on Middle Island, and perhaps several hundred on West Island (Gaymer, personal communication). From our observations in 1966, we would place the total at more than 10,000, but we would also stress the variability in habitat on South Island, and the need for caution in extrapolating sample counts, especially from lines of rapid traverse, which are likely to be the most open and hence most favourable locations. This order of magnitude contrasts strongly with the total of 1,000 estimated by James Spurs (Griffith, in Fairfield and others 1893, 153), and the general fear of imminent extinction and declining number in the second half of the nineteenth century. Wharton's sailors spent three days finding one tortoise in 1878 (Wharton 1883, 77). Fryer (1910, 258) comments that "it would be possible to live for years on Aldabra and never see a specimen." These reports may either indicate a spectacular increase in numbers in the last one hundred years, or

may simply result from the general rarity of tortoise in the areas of champignon and their concentration on platin at the remoter eastern end.

The greatest numbers of tortoise are found attached to the freshwater pools on the platin at the east end of South Island, though in the wet season they may be more widely-ranging. A few pools were seen crowded with tortoise (one with more than 80) in 1966, the tortoises lying in the mud and shallow water during the early morning (Plates 24, 25 and 28). Towards 10 a.m. they move to the shade of adjacent Pandanus, or Ficus at Takamaka (Plate 22), and stay there until sundown. We have no information on their nocturnal behaviour. Many of the pools, when almost dry, are green with organic matter, and this results in the formation of concentric drying marks of green or blue round the pool margins and on the backs of the tortoises. It was noticeable that tortoises with a given drying-mark colour were not found far from the corresponding pool. Many of the pools contained one or two dead tortoises. The animals are said to breed during the wet season, from January to April (Anon. 1920, Ch. 12, 8). On the South Island platin, droppings are found every few yards, and tortoises themselves are rarely out of sight. According to Fryer (1911, 420), they are also found on both West and Middle Islands, though on the latter he found only two specimens. Abbott (1893, 761) and Dupont (1907, 20) record that it became extinct on West Island in 1880, but was reintroduced a few years later by James Spurs, the lessee. In 1966 we found fresh droppings on Middle Island, but saw no tortoise. The tortoise clearly thrive in the platin habitat, feeding on sedges and grasses and the lower leaves of shrubs, even standing on their hind legs to reach these. The carrying capacity of the champignon is clearly much lower, and on the bare, seaward-coast champignon between Takamaka and Point Hodoul there are great numbers of bleached carapaces. Numbers of tortoises seem to wander into this barren area, and can be found sheltering in holes, under rare bushes, and even under washed-up tree-trunks on the cliff top, in what is during the dry season a completely waterless environment.

The conservation of the tortoises is discussed in Section 6(3)(a).

Aldabra has no snakes and no amphibians, and apart from the tortoises the land reptiles are represented by only two geckos and a skink. The geckos are Hemidactylis mercatorius (the H. gardineri of Boulenger 1911) and Phelsuma abbotti abbotti (the P. madagascariensis abbotti of Boulenger 1911 and Stejneger 1893). Hemidactylis is also found on Astove, Assumption and Cosmoledo (Honegger 1966b); Stejneger (1893) recorded H. mabouia from Aldabra, but Boulenger (1911) considered this to be identical with his H. gardineri. Phelsuma abbotti abbotti is also found on Assumption, and forms part of a series of species and subspecies of this genus in the southwest Indian Ocean, with P. abbotti menaiensis and a possible undescribed subspecies on Cosmoledo and P. astriata astovei on Astove (Mertens 1962, Honegger 1966b; also Boettger 1913). In 1966 we observed Phelsuma in symbiosis with the tortoises on South Island, running on the carapace and feeding on the Aedes mosquitoes which congregate round the soft neck and underparts of the tortoise; and a similar observation has been made by Honegger (1966b, 31). The skink Ablepharus boutonii peronii (Boulenger 1911) is of a species also found on Astove, Cosmoledo and Assumption.

4. Insects

By contrast the fauna is particularly rich in insects, especially by comparison with other Indian Ocean islands. While the Seychelles have more than two thousand species of insects recorded, none of the coral islands of the western Indian Ocean has more than one hundred, with the exception of Aldabra, which has more than 360 (Scott 1933, Legrand 1965). While this partly reflects the intensity of collecting by Abbott, Voeltzkow, Dupont, and especially by Fryer, himself an entomologist, it is also the result of the larger size and habitat diversity of Aldabra compared with the other coral islands, and also of its proximity to Madagascar.

The largest group represented is the Order Lepidoptera. After the Percy Sladen Expeditions there were 66 species recorded, with 7 endemics. Legrand's (1965) recent monograph, including the results of his own collecting together with that of the Italian Zoological Expedition of 1953, adds many new records of Microlepidoptera and increases the total to 127 species, 35 of which are endemic (about 28 per cent), and of which 12 are represented by endemic subspecies. The Order Coleoptera is represented by 93 species, of which 16 are thought to be endemic (about 25 per cent): three of these endemic species belong to endemic genera (*Keeta*, with two species, and *Bikasha*, with one: Maulik 1931). Other well-represented orders include the Diptera, Hymenoptera and Orthoptera. Scott (1933) gives biogeographical comments on each order, and Table 4 keys the entomological literature of Aldabra. Apart from cosmopolitan species, the insect affinities are dominantly Madagascan or East African, with few Oriental or Mascarene forms. Most of the possible endemic species are close to Madagascan forms, though so little is known of insect faunas in the Indian Ocean that Scott himself prefers the term "potential endemic" for species so far recorded nowhere else. The Aldabra insect fauna thus contrasts strongly with that of the Seychelles, which is dominantly Oriental in character (Scott 1933).

Apart from the species lists there is almost no information on the ecology and distribution of the insects of Aldabra, and the differences between the faunas of the champignon, platin and mangrove habitats. Information is also required on the insects associated with the large bird colonies.

Particular interest attaches to the mosquitoes of Aldabra because of the potential danger of malaria, which in fact occurred at Aldabra in 1908 and in 1930. Fryer collected *Aedes aegypti* (*A. fasciata*) at West Island, and *Aedes albocephalus* (*Reedomyia seychellensis*) and *Aedes fryeri* (*Culicelsa fryeri*) at Takamaka (Theobald 1912), the latter also taken by Dupont. Mattinly and Brown (1955) also record *Culex sitiens* Wied., collected by Dupont in 1907. *Anopheles gambiae* has been collected only once, in 1930 (Hermitte 1931), at the time of the malaria outbreak. This mosquito was then breeding only in small rainwater pools in West Island, and does not seem to have survived. In 1966 we took only *A. fryeri*.

Two species of horseflies taken in 1966 have been identified as *Aegophagamyia remota* and *Neavella albipectus*.

Table 4. Key to the Literature on the Insects of Aldabra

THYSANURA and COLLEMBOLA
- Carpenter 1916

ORTHOPTERA
- Bolivar 1912
- De Saussure 1897
- Linell 1893

DERMAPTERA
- Burr 1910

ISOPTERA
- Holmgren 1910
- Wasmann 1897

EMBIOPTERA
- Enderlein 1910

ANOPLURA
- Scott 1914

ODONATA
- Calvert 1898
- Campion 1913
- Linell 1893

HEMIPTERA
- Bergroth in Voeltzkow 1920b
- Distant 1913, 1917
- Green 1907
- Linell 1893
- Mamet 1943

NEUROPTERA
- Needham 1913

LEPIDOPTERA
- Aurivillius 1909
- Berio 1956, 1959, 1962
- Bourgogne 1963
- Fletcher 1910a, 1910b
- Fryer 1912
- Hampson 1908
- Herbulot 1962
- Holland 1895
- Karsch 1900
- Legrand 1965
- Meyrick 1911
- Viette 1958

COLEOPTERA
- Aurivillius 1922
- Bernhauer 1922
- Champion 1914
- Fairmaire 1896
- Gebien 1922
- Grouvelle 1913
- Kerremans 1914
- Kolbe 1902
- Linell 1897
- Maulik 1913
- Régimbart 1900
- Schenkling 1922
- Scott 1912, 1913, 1922b, 1926
- Sicard 1912

HYMENOPTERA
- Cockerell 1912
- Forel 1897, 1912
- Friese 1902
- Meade-Waldo 1912
- Turner 1911

DIPTERA
- Eaton 1913
- Edwards 1912
- Hermitte 1913
- Kertész 1912
- Lamb 1914, 1922
- Linell 1893
- Mattinly and Brown 1955
- Scott 1914
- Stein 1910
- Theobald 1912

5. Other groups

Little can be added on the other terrestrial groups to the results of collecting by Abbott, Voeltzkow, Dupont and Thomasset, and Fryer. The land crustacea have been reported by Rathbun (1894), Lenz (1905), and Borradaile (1910), who listed 17 species in 10 genera. The brachyuran decapod crustacea have recently been revised by Guinot (1964), using the collections made by Cherbonnier in 1954. She lists 33 species in 21 genera, including one new to science (Xanthias cherbonnieri). The land crustacean fauna is remarkable chiefly for the presence of the robber crab, Birgus latro, which is also reported from the Chagos Archipelago but is absent from the Maldives: clearly on Aldabra it cannot feed on coconuts. Cardisoma carnifex is common round the freshwater pools of the platin. There is a single earthworm (Ehlers 1897); a common scorpion (Isometrus maculatus, Hirst 1913); and several spiders (Hirst 1911), one of which, Nephila madagascariensis, is particularly prominent in the Mixed Scrub of the South Island platin, forming a large and strong web.

There is an inadequately known land molluscan fauna, which includes one endemic species, Rhachistia aldabrae (Von Martens, in Von Martens and Wiegmann 1898, 28, as Buliminus (Rhachis) aldabra), collected by a Mr Wilson in 1895. Other records listed by Connolly (1925) are Gulella (Molarella) gwendolinae, Gastrocopta tripuncta, Succinea mascarenensis, Isodora forkali, Assiminea punctum, A. parvula, and Truncatella valida. The microfauna is particularly poorly studied. In 1966, for example, we found a rich freshwater microfauna in the drying platin pools, including crustaceans (fairy shrimps Streptocephalus sp., conchostracans Bulimnadia sp., and ostracods Heterocypris sp.) and molluscs, including a species of Bulinus. We also obtained a semi-freshwater fish of the widespread gobiid genus Tamanka from the freshwater well at Cinq Cases: this was the first record of a freshwater fish from the atoll.

5. MARINE BIOTA

1. Turtles

The marine biota of the Aldabra group of islands is best known for its turtles: Aldabra, Cosmoledo and Assumption support "the greatest concentration of breeding turtles in the Indian Ocean in modern times, and perhaps in antiquity" (Parsons 1962, 47). It is, therefore, extraordinary that no field study of these turtles has ever been carried out, and that the available information is largely based on local reports and hearsay set down by infrequent visitors.

The green turtle, Chelonia mydas L. (Loveridge and Williams 1957, 472-484; Parsons 1962), is by far the most important on Aldabra, though it is now rare as a breeding species on Cosmoledo and may have vanished from Assumption. The hawksbill, Eretmochelys imbricata L., taken for its shell, is found in much smaller numbers, and at Aldabra has a distinctively lighter shell than elsewhere in the Seychelles, as a result, according to Fryer, of the muddiness of the lagoon. The loggerhead, Caretta caretta L., is also thought to occur, but does not seem to have been positively identified. Hornell (1927) draws attention to the fact that not only is the distribution of the hawksbill and the green turtle reversed (the former being abundant in the Seychelles and rare at Aldabra, and

vice versa), but also that their breeding seasons alternate. The hawksbill breeds from September to November, and comes up the beaches during the day; whereas the green, a nocturnal egg layer, lays from February through to September. Hornell believes that the green turtle appear from their feeding grounds, presumably in the Mozambique Channel, from December onwards, and begin to lay in February, perhaps in two groups of different origins (the main group in February-March, and a subsidiary group in May-September). However, there is no month in which turtles are not coming up the beaches to lay (Hornell 1927, 31). The numbers of turtles were declining rapidly by the end of the last century (Spurs 1892), and Hornell forecast ultimate extinction if exploitation continued under the lessee system without any attempt at conservation. Considerable losses of newly hatched green turtles were also said to have been caused by predation by herons and frigatebirds (Hornell 1927). Voeltzkow (in Boettger 1913) suggested that 3000 a year were lost in this way. Later surveys in 1948-49 (Wheeler 1953b) and more recently (Veevers-Carter 1962; Newman 1965; Gaymer 1966c) have shown that the decline in numbers has continued, though this is not precisely documented. Conservation measures and their results are considered in greater detail in Section 6(3)(b). Field studies to establish the status of the marine turtles at Aldabra and nearby islands are urgently required.

2. Other groups

Apart from the turtles, little is known of the marine biota, which does not appear to be rich. Voeltzkow made a small collection of marine fishes (Jatzow and Lenz 1899), echinoderms (Ludwig 1899), corals (Doederlein 1901), and marine mollusca (Thiele 1902, 244-246), but only the latter were at all thoroughly collected, and the fauna was typically Indo-Pacific. Travis (1959, 159-166, 182-188) draws attention to the abundance of Turbo on the forereef slopes on the east and south sides of the atoll, and this species is also found on the reef-flat boulder zone. The coral fauna appears curiously poor, by comparison with the period when the reef limestones were formed; so much so that Gardiner (1936, 426) drew a distinction between the decadent and eroding reefs of the Mascarene region, including Aldabra, and the flourishing, growing reefs of the Maldives and the Chagos. This conclusion is supported by Stoddart's own observations at Aldabra and in the Maldives. Apart from the forereef slopes, reef corals are only actively growing on the margins of the two main channels into the lagoon, and these are mostly massive slow-growing species: a few are listed by Matthai (1914, 1928). Fryer's small collection of marine algae was named by Madame Weber-van Bosse (1914). The commercial fishery potential of Aldabra was investigated by the Mauritius-Seychelles Fisheries Survey in 1948-49, and found to be disappointing (Wheeler and Ommanney 1953; Wheeler 1953a). The invertebrate fauna of the lagoon, which is almost entirely unstudied, must be considerable to support the large numbers of shore birds.

6. SETTLEMENT, EXPLOITATION, AND CONSERVATION

1. Human Settlement

The early history of human settlement at Aldabra is obscure. Voeltzkow (1897) summarises early knowledge, mainly from the charts in A. Grandidier's Atlas der Karten von Madagascar, from the sixteenth century onwards. Aldabra did not become well known until the middle of the eighteenth century, when Lacaze Picault and Jean Grossen called there in the Charles and the Elizabeth in 1742 (Findlay 1882; Keller 1901). According to Horsburgh (1852, 174-176), Aldabra was visited in August 1756 by a "Mr Morphey" (Nicolaus de Morphy), in November 1766 by the ship Asia, and in December 1815 by the Lord Castlereagh. Commander R. Moresby passed close by in August 1822, but did not land. Aldabra was visited in 1841 by Captain Jehenne in the ship La Prévoyante (Voeltzkow 1897, 41). The ship Euphrates, out of London for Karachi, anchored in the lagoon in 1862. At a much later date the German cruiser Königsberg hid in Main Channel for two months in 1915, before being destroyed by English warships on the African coast.

The atoll was apparently uninhabited in 1878, when H.M.S. Fawn, Commander Wharton, carried out the first hydrographic survey. In 1879, however, an attempt was made to settle by a party of 27 adults and 13 children, all Norwegians from Bergen, who arrived via Nossi-Bé to found a fishing station on communistic principles (Anonymous 1879; Reclus 1889, 155). The fate of this scheme is unknown. Shortly afterwards it was decided by the Government of Mauritius to exploit the atoll by leasing it commercially for a small annual rent. The first lease was allotted to Jules Cauvin of Mahé in 1888. Cauvin established a settlement at Ile Magnan in West Channels, where he planted coconuts while exploiting timber. In 1890 the lease passed to James Spurs, at a rent of Rs. 500 per annum, and he held it for ten years, moving the settlement to Ile Picard or West Island, its present site. Spurs had worked for many years as a manager at Diego Garcia in the Chagos Archipelago (Scott 1961, 165-169). The Administrator of the Seychelles considered that "the Government are fortunate in having secured Mr Spurs for a tenant; for it will be gathered from his report . . . that he is an observant man and a lover of Nature, nor do I think he is likely, to use an old and homely phrase, to kill the goose that lays the golden eggs by exhibiting that rapaciousness which has characterised the actions of others who have been there before him" (Griffiths, in Spurs 1892, 45). Nevertheless, Spurs proposed to take up to 12,000 green turtle a year from Aldabra, for what was then a "trifling" rent. He did, however, attempt to repopulate West Island with tortoises, warned of the disappearance of the hawksbill and of the consequences of taking many more female than male green turtles, and even brought Chinese to Aldabra from Mahé to make trepang. By the time of Voeltzkow's visit in 1895, there was a settlement at West Island of 20 Seychellois labourers in ten houses, growing maize and vegetables, and taking turtles and tortoises (Keller 1901; and also Fryer 1910 for an illustration). The earlier settlement site at Ile Magnan, and the site at Ile Michel, recommended after H.M.S. Fawn's survey as "the only suitable place for building a house" (Findlay 1882, 550), had both been abandoned.

The lease passed in 1900 to Messrs Baty, Bergne and Co., at a rent of Rs. 3000 per annum, and the company concentrated on fishing rather than on timber; and also planted many coconuts (cf. Baty 1896). In 1904 M. D'Emmerez de Charmoy became the lessee, with James Spurs as his manager; and his administration became notorious for its wasteful and inefficient exploitation of the turtle industry (Hornell 1927). D'Emmerez was still lessee at the time of Fryer's visit in 1908-9; and the atoll was leased in this way until 1945, when commercial exploitation lapsed temporarily. The lease was renewed ten years later, when in 1955 M. Harry Savy of Mahé obtained a 30 year lease, with an option on a further 20 years. His company employs up to 100 labourers to work the atoll, under contract from the Seychelles for periods of up to three years. They live in well-built wood and cement houses on West Island, and are supplied by schooner from Mahé. Rainwater is supplied from three large tanks (Plates 39 and 40). The company salts and dries fish for export, cuts mangrove for timber, collects a limited number of giant tortoises for export, and also takes the green turtle, maintaining a large turtle pen on the northernmost island in West Channels. Aldabra is leased jointly with Cosmoledo and Assumption.

No guano or phosphate ever seems to have been exported from Aldabra. Fryer (1911, 407) drew attention to the presence of phosphate, and Baker (1963, 107-110) estimated reserves at about 1000 tons, being uneconomic to work. He found no evidence of rich guano previously reported in the Cinq Cases area. One of the Western Channels, Passes Lanier, may, however, be named after one of the leading Seychelles guano companies.

The further prospects for economic development at Aldabra seem unpromising. The areas of sandy soil suitable for coconuts are very limited, and there is no possibility of extending the coconut industry. The Mauritius-Seychelles Fisheries Survey gave a disappointing picture of Aldabra's fish potential (Wheeler 1953a). It was estimated that eight men could produce 70 tons, at first, of fresh fish a year from the lagoon, falling to a steady figure of 12-16 tons per annum; and that eighty men could produce 460 tons per annum outside the atoll. The possibility of exporting orchella as an organic dyestuff (Dupont 1907, 28-29) collapsed with the development of synthetic dyes.

2. Introduced Animals and Plants

In 1966 the introduced mammals of Aldabra included goats, dogs, cats, rats and mice. Voeltzkow recorded the presence of a feral cat, though his narrative does not make clear where it was seen (Voeltzkow 1897, 66), and also rats and mice, in 1895 (Lorenz-Liburnau 1899). Abbott (1893, 762) and Fryer (1911, 417) considered the feral cats to be confined to South Island, and though an unidentified observer in 1906 considered they were "everywhere" he only saw them on South Island (Anon. 1920, Ch. 9, 5-7). The cats are said (Anon. 1920, Ch. 9, 7) to have been introduced by James Spurs to control rats, and that Spurs rejected the suggestion that only one sex should be introduced. Both Abbott and Fryer stated that the feral cats had exterminated the flightless rail, at least in the Takamaka area. Two were seen near Frigate Pool, at the east end of South Island, in 1966. Feral dogs were heard barking on South Island in 1966, but were not seen; they are reported to number only two, and to be of the same sex.

Goats were introduced by James Spurs when lessee in 1890. Griffith (in Fairfield and others 1893, 154) states that they were brought from Cosmoledo, but we have found no other reference to goats on that atoll. According to Dupont (1907, 13, 22) they were brought from Assumption, where they had been introduced by a whaler in c. 1887, possibly from Europa Island in the Mozambique Channel (Abbott 1893, 763). According to Dupont, they were soon exterminated on West Island (Dupont 1907, 22), though they were again reported there in 1905 (Anon. 1920, Ch. 9, 2). They became feral on South Island. Travis (1959, 178-181) describes considerable herds on the southern dunes, but in 1966 only one small group of four individuals was seen on two occasions at the east end of South Island. Prosperi (1957, 198) records goats at the east end of Middle Island, but this must be an error, as they are not otherwise recorded there. The feral goats at Aldabra do not seem to have reached the status of major pests that they have become on other islands, and do not appear to represent a major threat to tortoise food supplies.

Rats are thought to be more active predators; they probably feed on frigate and booby eggs and young, and possibly also on tortoise eggs and young, though not to a serious extent. Domestic fowl are also kept at West Island, and have become feral.

Introduced plants include such cultivated species as maize, cotton, sisal, and probably coconuts, together with common weeds such as Stachytarpheta, but these are all limited to the neighbourhood of the settlement and cultivated areas.

Because of their poverty in genera and species, island ecosystems normally have low ecological inertia and are specially liable to catastrophic invasion by animals and plants (Elton 1958). It is therefore remarkable that the effects of introduced species at Aldabra have so far been so limited; though the possible effects of the spread of the major predators and competitors already present on South Island to other parts of the atoll must not be ignored. It is fortunate that the introduction of rabbits, hares, and cattle--all potential herbivore competitors for the tortoises--which was proposed by Dupont (1907, 32) to augment food supplies, never took place.

3. Exploitation and Conservation

The scientific importance of Aldabra was not realised until the latter part of the nineteenth century, after the disappearance of tortoises and rare land birds from the Mascarene Islands. When the Government of Mauritius first proposed to lease the islands for woodcutting, there was a considerable outcry, and several species are now protected by legislation. "Legislation is one thing," however, "and the enforcement of laws against fishermen on the open sea or in uninhabited places is another" (Griffith, in Spurs 1892, 44).

(a) Tortoises

Active conservation of the tortoises was begun by the letter sent to the Governor of Mauritius in 1874 by a group of naturalists which included Charles Darwin, Joseph Hooker and Richard Owen (Günther 1877, 20-21), when it was first proposed to establish a woodcutting colony on the atoll. Particular concern

was expressed over the "imminent extermination of the Gigantic Land-Tortoises of the Mascarenes". Even at that time it could be stated that "Aldabra is now the only locality where the last remains of this animal form are known to exist in a state of nature", and it was argued that

> "The rescue and protection of these animals is, however, recommended . . . less on account of their utility . . . than on account of the great scientific interest attached to them. With the exception of a similar tortoise in the Galapagos Islands (now also fast disappearing), that of the Mascarenes is the only surviving link reminding us of those still more gigantic forms which once inhabited the continent of India in a past geological age. . . . It flourished with the Dodo and Solitaire; and whilst it is a matter of lasting regret that not even a few individuals of these curious birds should have had a chance of surviving the lawless and disturbed conditions of past centuries, it is confidently hoped that the present Government and people . . . will find a means of saving the last examples of a contemporary of the Dodo and Solitaire" (quoted in Günther 1877, 20-21).

Leasing of exploitation rights on the islands proceeded, however, without legislation to protect the tortoises. For a number of years they were conserved by the private philanthropy of the Hon. Walter (later Lord) Rothschild, who entered into an agreement by which he paid one half of the lessee's annual rent (Rs. 1500 per annum of a total rent of Rs. 3000) on condition that the tortoises were rigidly protected. This agreement was first made with Messrs Baty, Borgne and Co., the lessees in 1900-04, and was later transferred to their successors (Dupont 1907, 15-16).

No protective legislation covering the tortoises was passed until recently (Lane 1953a, 1953b), although the species could have been scheduled (but was not) under the Wild Birds and Animals (Protection) Ordinance of 1906. Action was eventually taken (Proclamation 4 of 1961) under the Customs Management Ordinance, to prohibit the export of the giant tortoise from the Seychelles without the written authorisation of the Colonial Secretary (Statutory Instrument 7, 1961: Seychelles Gazette, Supplement, 13 February 1961, p. 40). There is apparently no legislation concerning the taking of tortoises from Aldabra, or the killing of tortoise on the atoll. The Governor of the Seychelles has powers, however, to "make regulations for the protection of wild animals" under the revised Ordinance to provide for the Protection of Wild Animals and Birds, No. 37 of 1961 (Seychelles Gazette, Supplement, 26 December 1961, pp. 163-165). Under the terms of the 1955 commercial lease (see Section 6(3)(d)), the lessee is required to protect the tortoises and not to interfere with them. The West Island settlers kill tortoise occasionally for food, and though the total annual loss may be quite high, it is by no means catastrophic. If any future development of Aldabra were to exclude tortoises from the platin, however, there would certainly be a considerable fall in numbers, and further protective legislation would be necessary.

(b) Turtles

Commercial exploitation of the turtles, mostly the green, began about 1906, though they had been taken less systematically for several years before this.

Fryer (1910, 260) regretted their "wasteful slaughter", which even then (1908-09) was resulting in a considerable decline in numbers (Fryer 1911, 421-423). In particular the practice of turning females on the beaches when they came ashore to lay had greater long-term effects on the population than that of harpooning males at sea, particularly when carried out early in the season. Hornell, commissioned to enquire into the state of the Seychelles turtle industry, reported that at Aldabra "the policy of the lessees cannot but lead to an early extinction of the trade" (Hornell 1927, 37). At this time the total number of green turtle taken from the islands of Aldabra, Assumption and Cosmoledo was of the order of 3000-4000 per annum. Hornell made specific recommendations for conservation and for the revision of original conservation legislation which dated from the beginning of the century (Ordinances 16 of 1901 and 2 of 1904). The new legislation (Ordinances 5 of 1925 and 5 of 1929) specified minimum sizes for both green and hawksbill turtles taken, prohibited the taking of buried eggs, barred the use of torches at night and the taking of turtle within 1000 metres of the high water line, and laid down control procedures (Lane 1953a, 114-120; 1953b, 195-200). The major recommendation which was not adopted was that for a close season from December 1 to the last day of February, during which no turtle might be taken. Hornell also proposed the control, at Aldabra, of frigate birds, herons, and the ibis, all of which (but especially the frigate) were said to kill large numbers of newly hatched turtle. Dupont (1907, 29) had previously proposed the extermination of frigates and herons by shooting and poisoning, for the same purpose, but neither proposal was fortunately accepted.

In spite of the legislation of 1925 and 1929, the numbers of green turtles continued to decline, and by the time of the Mauritius-Seychelles Fisheries Survey the number taken annually was less than 1500. Following this survey, Wheeler (1953b) again put forward Hornell's close-season recommendations, and these were adopted in Government Notice 452 of 1948. Under this, the close season, during which no green turtle might be taken at Aldabra or Cosmoledo, was defined from December 1 to the last day of February; and it was further made illegal to turn turtle on the beaches between March 1 and May 31 (Lane 1953a, 200-201). This last provision was designed to protect females during the earlier of their repeated egg-laying visits. Minor changes in this legislation were made by Ordinance 22 of 1957 (Seychelles Gazette, Supplement, 23 December 1957, pp. 64-66).

There has been no detailed work on the Aldabra turtles since the Fisheries Survey, but numbers of the green turtle continue to decline, and those of the hawksbill are now very low. A further revision of the Turtles Ordinance was made by the Female Turtles Protection Regulations, 1962 (Seychelles Gazette, Supplement, 23 July 1962, p. 44), in which the close season, during which it is made illegal to catch, kill, harpoon or otherwise take female turtles, is extended from December 1 to March 31. This originally applied to both the green turtle and the hawksbill on Aldabra, Cosmoledo, Farquhar, Providence and other islands; but the hawksbill was deleted in revised regulations later the same year (Female Turtles Protection (no. 2) Regulations, 1962: Seychelles Gazette, Supplement, 1 October 1962, p. 68). Subsequently, the use of underwater guns or other underwater equipment for taking the hawksbill was prohibited (The Hawksbill Turtle Protection Regulations 1963: Seychelles Gazette,

Supplement, 3 June 1963, p. 48); and this provision specific to the hawksbill was later revoked and added as an amendment to the Turtles Ordinance, prohibiting the use of underwater equipment for either the green turtle or the hawksbill (Ordinance 1 of 1964: Seychelles Gazette, Supplement, 9 March 1964, pp. 9-11).

Under the terms of the 1955 commercial lease, not more than 500 green turtles per annum may be taken on or within three miles of Aldabra, and none at all at Cosmoledo and Assumption, without written permission from the Seychelles Government, and no turtle eggs may be taken on any of the islands (Article 9(a)).

(c) Birds

Birds have long been protected in the Seychelles under the Wild Birds and Animals (Protection) Ordinance of 8 December 1906 and the Plumage Birds (Exportation) Ordinance of 21 February 1914. The former gave the Governor of the Seychelles powers to prohibit the killing or taking of any scheduled bird, or the taking of its eggs, with exceptions permitted for scientific or natural history purposes (Lane 1953a, 124-125). The schedule of birds thus protected (Wild Birds and Animals Protection Ordinance of 21 June 1941) included the following species at Aldabra (nomenclature revised; original nomenclature given in brackets):

Phoenicopterus ruber roseus	(Phoeniconaias minor)
Threskiornis aethiopica abbotti	(Ibis abbotti)
Phaethon lepturus lepturus	(Phaethon lepturus)
Alectroenas sganzini minor	(Alectroenas minor)
Dryolimnas cuvieri aldabrana	(Dryolimnas aldabranus)

(Lane 1953b, 204-205). The schedule of birds protected under the Plumage Birds (Exportation) Ordinance includes (by Proclamations 5 of 1914 and 1 of 1947), for Aldabra, all the above except Phaethon lepturus lepturus, together with:

Phaethon rubricauda rubricauda	(Phaethon rubricauda)
Streptopelia picturata aldabrana	(Turtur aldabrana)
Dicrurus aldabranus	(Buchanga aldabrana)
Zosterops maderaspatana aldabrensis	(Zosterops aldabrensis)
Caprimulgus madagascariensis aldabrensis	(Caprimulgus aldabrensis)
Centropus toulou insularis	(Centropus insularis)
Foudia eminentissima aldabrana	(Foudia aldabrana)
Nectarinia sovimanga aldabrensis	(Cinnyris aldabrensis)

(Lane 1953b, 193). All these protected birds are land birds except for the tropicbirds, the sacred ibis, and the flamingo. The Bird's Egg Ordinance of 1933, designed to protect the Sooty Tern in the Seychelles, and subsequently extended and many times revised (chiefly by the Collection of Birds' Eggs Regulations, 1957, and the Collection of Birds' Eggs Regulations, 1962: Seychelles Gazette, Supplement, 17 May 1957, pp. 25-26, and 4 June 1962, pp. 32-34), has never extended to Aldabra.

In 1961 the Wild Birds and Animals (Protection) Ordinance and the Plumage Birds (Exportation) Ordinance, under which all the above birds were protected, were both revoked, and replaced by a single Ordinance to provide for the Protection of Wild Animals and Birds (Ordinance 37 of 1961: Seychelles Gazette, Supplement, 26 December 1961, pp. 163-165). This Ordinance gives the Governor in Council power to "make regulations for the protection of wild animals and birds". In addition to the two earlier ordinances, all the proclamations under them were also revoked; so that presumably new schedules of animals and birds protected must be issued.*

Under the terms of the 1955 commercial lease, no birds' eggs may be commercially exploited, and the only birds which can be taken are crows and poultry.

(d) Conservation Prospects

Following the Darwin-Hooker appeal over the tortoises, and the gradual development of protective legislation for tortoises, turtles and birds, commercial exploitation of Aldabra on a small scale became accepted. The next major issue was in the early 1950s, when it was proposed to settle 1200 Seychellois, discharged from the Army Pioneer Corps in the Middle East, on the atoll, the last commercial lease having lapsed in 1945 and not having been renewed. Fosberg (1954) prepared a memorandum on the scientific importance of Aldabra, and the inadvisability of this step, and the proposal was dropped, probably as much on account of the inhospitable environment as for scientific reasons.

Following the visit of the Calypso to Aldabra in 1954, Commander J.-Y. Cousteau became interested in the conservation of the atoll, at a time when the commercial lease was about to be renewed. Cousteau's proposal to lease the atoll "as a wildlife sanctuary and . . . tropical research centre on an island almost uncontaminated by man" (Cousteau 1963, 149) was rejected, but his publicity in London (Cousteau 1963, and also Cousteau 1959) led to important conservation clauses in the commercial lease concluded between the Seychelles Government and Mr H. Savy, of Mahé, on 2 and 5 February 1955. Proposals for turning Aldabra into a commercial breeding ground for Chinese ducks were also rejected. The lease is for 30 years, with an option on a further period of 20 years. Article 5 of the lease states:

> "That the lessee shall respect South Island in the atoll of Aldabra as a nature reserve. Without prejudice to the generality of the implications of this condition the lessee hereby covenants:--
> (a) That there shall be no settlement on South Island.
> (b) That he shall protect all animal life on South Island.
> (c) That he shall not introduce any new animal or plant on South Island.

*"The Commissioner, British Indian Ocean Territory, states that although the Protection of Wild Birds and Animals Ordinance was published in 1961, it did not come into force in the Seychelles until 1966, i.e., after the formation of the British Indian Ocean Territory on 8 November 1965. Hence it does not apply to Aldabra, where the Wild Birds and Animals (Protection) Ordinance (Cap. 24) and the Plumage Birds (Exportation) Ordinance (Cap. 19) together with the Regulations made under these Ordinances are still in force. The schedules of protected birds listed in Chapter 2 consequently still apply to Aldabra."

(d) That he shall not exploit any of the resources of the said South Island except mangrove which he shall have the right to cut and remove."

Article 6 allows "unrestricted exploitation" of coconuts, mangroves, seaweed, shell fish, sea slugs, fish, goats, crows and poultry. Quarrying of stone (Article 9(b)) and clearing of woodland (Article 10) are restricted; clearing by fire is prohibited without permission (Article 11). The total resident population is not to exceed 200 persons without permission (Article 17).

Articles 12, 13 and 14 add further conservation measures:

"12. That the lessee shall be the guardian and protector of all wild life and all the resources of the Islands and of the surrounding seas. The lessee shall ensure to the best of his ability that, save as provided in this lease, no wild birds, tortoises or other animals are molested, deprived of their proper sustenance, disturbed, taken or killed by any person not holding the express permission in writing of the lessor.

13. That apart from the restricted and unrestricted exploitation detailed above the lessee shall in no way exploit or permit the exploitation of the animal and mineral resources of the Islands or surrounding seas without the express permission in writing of the lessor.

14. That the lessee shall not exploit for export or otherwise birds' eggs without the express permission in writing of the lessor."

An important clause, Article 16, gave the Government of the Seychelles powers to establish a research station on the atoll:

"16. That the lessor reserves the right for the Government of Seychelles or for any person, body of persons corporate or incorporate, sponsored by the Government of Seychelles, to establish on any of the Islands, scientific research stations for the purposes of zoological, oceanographic and other scientific researches. The lessee shall be bound to grant, free of any charge, all the reasonable facilities on the Islands for the establishment of the said research stations and shall do everything in his power to promote and facilitate any researches that may be carried out."

Finally, Article 21 gives the Government of Seychelles power to resume possession of the islands at any time for a "public purpose", defined to include "the building of lighthouses, Police Stations, or other public buildings and all Admiralty and War Department requirements".

In 1964 it became known that the Ministry of Defence was considering the establishment of defence facilities, including an airfield, at Aldabra. This proposal, following discussions between the Ministry of Defence and the Royal Society, led to scientific participation in the joint B.B.C.-Ministry of Defence expedition in 1966, the formulation of preliminary conservation policies (Stoddart 1966b), and to the planning of a programme of further scientific work on the atoll, beginning with the Royal Society Expedition to Aldabra 1967-68.

The Ministry of Defence interest also led to a change in the status of Aldabra and certain other islands. Since 1903, when the Seychelles administration became independent of that of Mauritius, Aldabra has been administered from the

Seychelles as part of that colony, and in fact had been so administered informally since the 1880s. By the British Indian Ocean Territory Order in Council, 1965, however, Aldabra was detached from the Colony of Seychelles to form, with Farquhar, Desroches, and the islands of the Chagos Archipelago, a new Territory. Under the British Indian Ocean Territory Order 1965 and the British Indian Ocean Territory Royal Instructions 1965 (Seychelles Gazette, Supplement, 13 December 1965, pp. 184-193), the Territory is to be governed by a Commissioner, with powers of legislation, and laws in force in the individual islands at the time of the formation of the Territory are to continue to be valid. The first Commissioner of the B.I.O.T. is the Governor of the Seychelles; and the laws of the Seychelles will continue to apply and to be enforced in the Territory, including Aldabra (Ordinance to provide for the exercise of powers and duties in Seychelles in respect of the British Indian Ocean Territory, for the enforcement of process and the execution of judgment in Seychelles issued or given by Courts in the exercise of their jurisdiction in respect of the British Indian Ocean Territory, Ordinance 27 of 1965: Seychelles Gazette, Supplement, 20 December 1965, pp. 131-132). All the conservation measures so far discussed remain in force, therefore, in spite of the change in the status of Aldabra. A further measure which also remains in force is the designation of West Island (Picard) as a port for the purposes of Customs laws, under Proclamation 11 of 1956 (Seychelles Gazette, Supplement, 8 October 1956).

7. A NOTE ON PLACE NAMES

Place-name usage on Aldabra is complicated by the fact that the atoll is a British possession, but most of the place names were given by French-speaking people, and the local inhabitants speak a French patois. English names have been given to some of the larger islands, and are to some extent used locally, but most of the smaller topographic features only have French names. In at least one case (Johnny Channel) a topographic feature has an English but no French name. It is not therefore possible to adhere to a toponymy either completely English or completely French. A further complication is added by the fact that some features have been named by passing vessels or occasional visitors, the name has had brief usage and has appeared in the literature, but is no longer used locally and may be considered dead.

A basis for accepted toponymy is given by the two Department of Overseas Surveys 1:25,000 map sheets of Aldabra, which where possible give precedence to English names adding the French in brackets, and otherwise using French names where no English name is available. This usage is generally followed in these papers, with a few exceptions mentioned below. Where a choice of names exists, regard should be given to established usage, and as a further principle, new names should not be unnecessarily introduced.

1. Main islands

Polymnie

No alternative name is known. The name is presumably of French origin, and the correct version is thus Ile Polymnie, though the D.O.S. uses Polymnie Island.

Middle Island

This name is used on the 1878 Admiralty chart, by Fryer (1911), and on the D.O.S. map, all with the subsidiary form Ile Malabar or Malabar Island. Abbott (1893) uses "North or Middle Island" and "Ile Nord". The usage of of North Island has come into the zoological literature through Rothschild (1915). Middle Island is accepted.

South Island

This name is used on the 1878 Admiralty chart and by Fryer (1911) (who uses "Main or South Island"), and also on the D.O.S. map. Abbott (1893) uses Grande Terre. South Island is accepted.

West Island

This name is used on the 1878 Admiralty chart, by Fryer (1911), and on the D.O.S. map. The 1878 chart and Fryer quote as a subsidiary name Ile Picard, and the D.O.S. map uses the hybrid Picard Island. These names predate the existence of the settlement, and hence there is no case for using the name Settlement Island. West Island is accepted.

2. Lagoon islands

Ile Esprit

Ile Esprit appears on the 1878 Admiralty chart, in Fryer (1911), and on the D.O.S. map as subsidiary to "Euphrates Island". Esprit has priority and is used locally: the name Euphrates derives, according to Findlay (1882), from the visit of the ship Euphrates en route from London to Karachi in 1862. This does not seem a sufficient basis to establish the name. Abbott (1893) uses Ile Sepoy, which must be a misunderstanding or misprint. Ile Sylvestre is used for the small adjacent island on the 1878 chart, by Fryer (1911), and on the D.O.S. map, and has no English alternative name. Esprit and Sylvestre are accepted here.

Ile Michel

Ile Michel appears on the 1878 Admiralty chart, in Fryer (1911), and on the D.O.S. map as subsidiary to "Cocoanut Island". Cocoanut Island was introduced by Wharton during the Fawn survey, when coconut trees were planted there; and Michel has precedence and is used locally. Abbott (1893) also uses Michel. Michel is used here.

Other islands

The D.O.S. map gives French names to a number of other lagoon islands, all of which are acceptable and are used here. The name Ile Magnan should be used for the largest island in West channels, and appears on the 1878 chart.

3. Channels

The names Main Channel, East Channel, and West or Western Channels are used on the D.O.S. map and the 1878 chart, with the subsidiary names of Grande Passe, Passe Houareau, and (in the 1878 chart) Passes Lanier, respectively. This usage is followed here. The D.O.S. map gives French names to the minor channels of West Channels (Passe Femme, Passe du Bois, Passe Mannian, Passe Grabeau), and these are also accepted apart from Mannian, which is properly Magnan. Johnny Channel has no French equivalent.

4. Land names

The D.O.S. map gives a number of French names for dunes, beaches and headlands, and all are accepted. On South Island it is useful to add Takamaka (1878 chart), Wilson's Well (Dupont 1907),and Abbott's Creek (1878 chart and Fryer 1911). Bras Takamaka of the D.O.S. map is preferred to the East Bay of Fryer (1911). The names Camp Frigate, Ile Verte, and Couroupa are used by Fryer (1911) and may be usefully retained. Couroupa is also used by Dupont (1907), and is apparently the same as the D.O.S. feature named Anse Tamarind, though this is in a different location from Fryer's (1911) Tamarind Point: this should be resolved in the field. Fryer's (1911) location named Camp Frigate is named "Opark" on the D.O.S. map of Middle Island.

Two further names are proposed here for pools on the platin of South Island: Frigate Pool, a large pool used by diving frigate birds, and Flamingo Pool, the largest freshwater pool on the island, a name in local usage though we have not been able to discover any evidence of flamingoes using it. These names are located in Figure 3.

Chapter 3

SUMMARY OF THE ECOLOGY OF CORAL ISLANDS NORTH OF MADAGASCAR
(Excluding Aldabra)

D. R. Stoddart

Department of Geography, Cambridge University

1. Assumption

2. Astove

3. Gloriosa

4. Cosmoledo

5. Farquhar (Joao de Nova)

6. St Pierre

7. Providence

The need to establish the ecological status of Aldabra among the islands of the southwest Indian Ocean has required the collection of information on several sea-level and elevated atolls and reef-islands in this area, and in particular on the islands between Aldabra in the west and Providence Bank in the east (Figure 6). Seven islands are included: Assumption, Astove, Gloriosa, Cosmoledo, Farquhar, St Pierre, and Providence. Much of the information on the ecology of these islands is very old, dating from the cruise of the Alert in 1882, the visit by Abbott in 1892-93, by Voeltzkow in 1895, the Valhalla in 1906, the Percy Sladen Expedition in 1905, by Fryer in 1908 and by Dupont, Thomasset and others early in this century. Much of the information on particular groups of animals is scattered through the Percy Sladen Expedition Reports and other lists, and has never been brought together for each island. Furthermore, most of the collections were made in the period

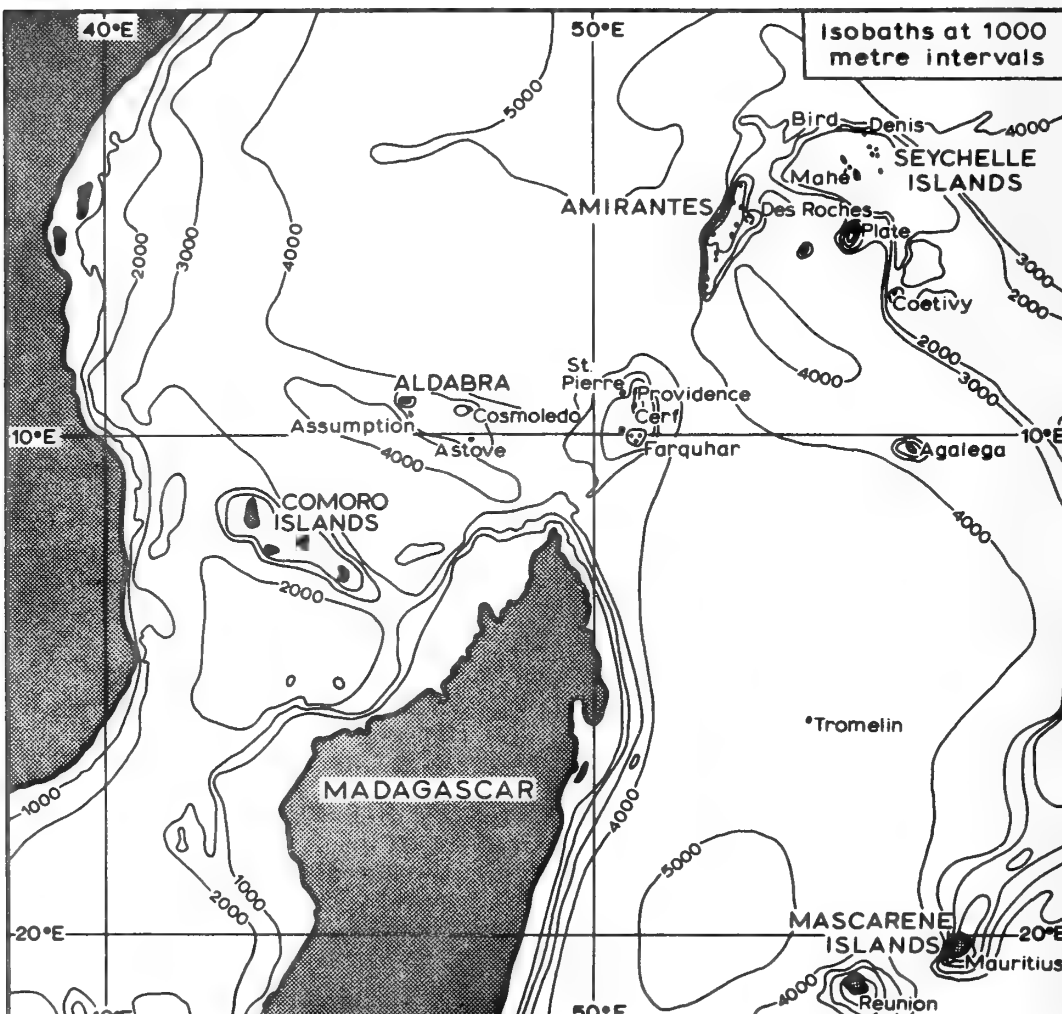


Figure 6.--Islands and Bathymetry of the South West Indian Ocean

preceding the mining of guano, during which the natural vegetation was destroyed on several islands and certain birds and other animals became extinct. In more recent years, we have the observations made by Vesey-Fitz-Gerald on the vegetation and the birds in 1937, and the largely geological observations of Baker and Piggott in 1960-61. The Bristol Seychelles Expedition spent some hours ashore on Cosmoledo Atoll (Menai Island) on 9 November 1964 and on Assumption on 10 November 1964. The following year R. Gaymer, of that expedition, made a short visit to Cosmoledo on 1 October 1965 and to Assumption on 3 October 1965. I am grateful to R. Gaymer for sending me a copy of his observations on these islands.

Because the information on these islands is so scattered, the salient features of the ecology of each of the seven islands or atolls listed are here summarized, with reference particularly to the vegetation, the reptiles, and the birds. In preparing this summary, lists were compiled of the plants collected or recorded from each island, based on published accounts, particularly those of Dupont (1907) and Hemsley (1919), and use was made of the lists of birds by Watson, Zusi and Storer (1963). For the information on insects I have relied on the summary by Scott (1936) and no special search has been made of the papers in the Percy Sladen Expedition Reports. The most important general sources are Coppinger (1883), Dupont (1907), Fryer (1911), Vesey-FitzGerald (1940, 1941, 1942), Watson, Zusi and Storer (1963), and Baker (1963). The summary account of each island does not contain citations for each statement, but a list of the more important references, less important references, and maps is appended to each: full citations are given in the "Bibliography of Aldabra" in this Bulletin.

This summary does not treat the Amirantes and Desroches, Cargados Carajos, Agalega, or Tromelin.

1. ASSUMPTION 9°46'S., 46°31'E.

Assumption is an elevated reef island 20 miles south of Aldabra, 3.75 miles long and 0.3-1.0 miles wide. The deeply dissected reef rock rises to 20 ft above sea level, with dunes on the east and south sides rising to 90 feet. Early in the century the island was wooded in the west and southwest, and the centre was only thinly vegetated. The vegetation resembled that of Aldabra, and 68 species of flowering plants have been recorded, three of them endemic (Panicum assumptionis, Eriochlea subulifera, Stenotaphrum clavigerum). The dunes are covered with Sporobolus and clumps of Sclerodactylon, with patches of Suriana, Scaevola and Tournefortia. The centre of the island had a few Hibiscus bushes, and coconuts are planted on sand along the west shore. The rest of the island has been stripped of vegetation during guano-digging, and there are now only a few stunted bushes in holes and pits, the ground being covered with Plumbago aphylla. Some Casuarina have been planted on the west coast. No mangroves are recorded.

Tortoises formerly existed here, and Fryer found their remains. There is a skink Ablepharus boutonii, and two geckos, Phelsuma abbotti abbotti and Hemidactylus mercatorius. 65 species of insects are recorded. Birgus latro was common in 1906. Marine turtles formerly nested here in large numbers, but only a few are reported to do so now.

Large numbers of boobies and terns formerly bred on the island, but have disappeared as a result of mining operations. Abbott's Booby, Sula abbotti, is now extinct on Assumption and is found only on Christmas Island. Vesey-FitzGerald gives the date of its disappearance as 1926. Sea and shore birds recorded as breeding on Assumption are Sula abbotti (extinct), Butorides striatus, Ardea cinerea, Egretta garzetta dimorpha, (which may also be extinct), and possibly Sula sula. Others recorded from the island are Sula dactylatra melanops, Sterna sumatrana mathewsi, Gygis alba monte, Phäethon rubricauda rubricauda, and Dromas ardeola. Resident land birds recorded are Streptopelia picturata coppingeri, Nectarinia sovimanga abbotti, Centropus toulou assumptionis, and Dryolimnas cuvieri abbotti. The rail, collected by Abbott in 1892 and described by Ridgway in 1893 and 1894a, became extinct between 1906 and 1937. The coucal and turtledove may also have disappeared. Gaymer recorded Corvus albus in 1965.

Guano reserves are the largest in the western Indian Ocean: 161,000 tons were exported during 1926-1945, and Baker estimates the remaining reserves at 160,000 tons. Mining ceased in 1945, but has started again since 1955; a mechanical crusher and light railway have been installed. Goats were introduced in early 1887 by a whaler, became feral, and were later used to colonise Aldabra; Abbott states that they were brought from Europa Island in the Mozambique Channel. Nicoll found twenty in 1906, but according to Gaymer they no longer exist. Nicoll also found numerous rats which were threatening to eliminate some of the rarer birds.

Main references: Abbott 1893, 763; Baker 1963, 101-106, 124-126; Dupont 1907, 12-13; Fryer 1911, 431-433; Nicoll 1906; Nicoll 1908, 107-113; Ridgway 1895, 520-523; Vesey-FitzGerald 1940; Vesey-FitzGerald 1941; Vesey-FitzGerald 1942, 12-13; Watson, Zusi and Storer 1963.

Additional references: Honegger 1966b; Ridgway 1893; Ridgway 1894b; Vesey-FitzGerald and Parker 1947.

Map: Baker 1963, 102.

2. ASTOVE 10°06'S., 47°45'E.

Astove is an elevated coral atoll 3.5 miles long and 2.5 miles wide, consisting of a reefrock rim 15 feet high, with sand dunes 45-50 feet high on the east coast. According to Baker reefrock covers 583 and sand 642 acres. The lagoon averages 3-4 feet in depth, with a maximum of 10 feet, and the entrance dries at low water. The fringing reef is 200 yards wide.

The dunes are covered with Suriana on the windward side, and with Scaevola and Tournefortia to leeward. Lagoonward of the dunes, champignon is covered with Pemphis thicket. The lagoon is filled with fine sediment, and is ringed with scattered Avicennia trees, but otherwise there is no mangrove. On the western lagoon shore, beach ridges are colonised by Sporobolus, and planted with coconuts and Casuarina. Pemphis grows on bare reefrock, and Scaevola and Tournefortia on sand. The sea coast on the leeward side has a thicket of Suriana, Scaevola and Tournefortia. A deciduous scrub covers the surface on the wider parts of the eastern side, with frequent Pisonia trees. 59 species of plants are recorded from Astove.

Tortoises formerly occurred here, according to Rothschild, and Fryer reports the finding of possible remains. Other reptiles include Phelsuma astriata astovei, Hemidactylus mercatorius, and possibly Ablepharus boutonii. Fryer also found that insects were numerous (27 species are recorded) and butterflies especially common. The land birds include Nectarinia sp., Zosterops maderaspatana, and a flightless rail, Dryolimnas cuvieri. Abbott reported the rail from hearsay, but it was probably extinct by 1906. Large numbers of Egretta garzetta have recently been recorded, together with Ardea cinerea and Butorides striatus. There are records of Bubulcus ibis ibis, Thalasseus bergii thalassina and possibly Demiegretta asha. Sula sula may be the only breeding sea bird; Corvus albus and Cisticola cherina have appeared; and there is a record of Hydroprogne caspia.

Guano is found on the west side, and has been mined since 1927. 70,000 tons have been reported, and 5000 tons are left, according to Baker. Most of the native vegetation in the guano area has disappeared, though some Pisonia grandis and occasional Sideroxylon inerme remain. It has been replaced by Plumbago aphylla, with Dactyloctenium pilosum and Stachytarpheta indica; Agave and Gossypium are also found. Coconuts are grown on the west side, though not very successfully, and maize has been grown in the dunes.

Main references: Baker 1963, 92-97; Dupont 1907, 2-8; Fryer 1911, 426-428; Piggott 1961, 6-8; Vesey-FitzGerald 1942, 10-12; Watson, Zusi and Storer 1963.

Additional references: Honegger 1966b; Vesey-FitzGerald 1940; Vesey-FitzGerald 1941.

Map: Piggott 1961; Baker 1963, 94.

3. GLORIOSA 11°34'S., 45°13'E.

The Gloriosa Islands are situated 114 miles west-north-west of Madagascar, and consist of two sandy islands with a grass-covered rock between them. Gloriosa, the larger island, is 1.5 miles long, and has dunes 50-60 feet high on its lee side, and a central tidal marsh which dries at low water. Ile du Lise, three miles away, is smaller, but has a dune 30 feet high, and also beachrock and conglomerate. Coppinger found a block of basalt on the reef, together with quartz pebbles.

Little is known of the biota. Gloriosa has been planted with coconuts and the "dense growth of virgin forest" seen by Coppinger in 1882 has since been cleared. Ile du Lise still has woodland on it, with Ficus, Hibiscus and Scaevola, and Pemphis in the central swamp. Maize used to be grown in large amounts on Gloriosa. Coppinger collected on the islands in 1882, and they were also visited by Abbott and Nicoll. According to Hemsley, Abbott found mangroves 50-60 feet high, but Abbott's actual record was of sand dunes. 30 species of plants have been recorded.

According to Rothschild, tortoises formerly existed on Gloriosa, but no supporting evidence for this can be found. Abbott records three small reptiles: Hemidactylus mabouia, Ablepharus gloriosus, and Zonosaurus madagascariensis. Nicoll found numerous butterflies and moths, and (on du Lise) Coppinger found many spiders and hermit crabs. Both Coppinger and Nicoll report Birgus latro on du Lise but not on Gloriosa. Green and hawksbill

turtles used to nest on Gloriosa and may still do so. The known resident land birds are Streptopelia picturata coppingeri, Hypsipetes madagascariensis grotei, Nectarinia sovimanga sovimanga, and Zosterops maderaspatana maderaspatana; together with Corvus albus, which is common. Nesting sea-birds include Sula sula, Fregata sp., Sterna fuscata, and Anous stolidus pileatus: large numbers of the noddies were nesting in 1906 on the rock between the islands. Sula abbotti may also have bred in the past. Phäethon rubricauda rubricauda may also breed, and other species recorded are Dromas ardeola, Sterna sumatrana mathewsi, Thalasseus bergii thalassina, and Thalasseus bengalensis. Two vagrants and one migrant are also recorded. The domestic fowl, Gallus gallus, has become feral. Feral cats were common in 1893, and were reducing the numbers of birds. In 1882 there were abundant brown rats on both islands.

Main references: Abbott 1893, 763-764; Coppinger 1883, 237-240; Coppinger 1884; Nicoll 1906, 686-692; Nicoll 1908, 100-106; Watson, Zusi and Storer 1963.

Additional references: Holland 1896; Ridgway 1895, 524-526.

Map: Guilcher and others 1965, 14, fig. 4.

4. COSMOLEDO 9°41'S., 47°35'E.

Cosmoledo is an atoll 9 miles long and 7 miles wide, with a lagoon 5 miles in diameter with maximum depth of 4-1/4 fathoms. There are five main islands and several smaller ones on the atoll rim, which has an average width of one mile. Menai Island has the largest area, but Wizard Island or Grande Ile, 2 miles long, is the longest. The islands are formed of uplifted reefrock, much eroded, reaching 12-15 feet above sea-level, with large amounts of sand banked against the rocky remnants.

At Menai Island on the west rim the seaward coast (leeward) has a dune scrub with Guettarda; dunes rise to 40 feet at the north end. The lagoon coast has mangroves 80 feet tall, with a succession of Avicennia-Bruguiera-Rhizophora from sea to land. Dunes are also found inside the mangrove. Pemphis scrub covers champignon in the centre of the island. The eastern islands, Polyte and Wizard, have a seaward dune fringe up to 55 feet high, covered with Sporobolus and Suriana on the seaward side, and with Tournefortia to leeward. Pemphis again covers the reefrock. The smaller islands are rocky, with Pemphis, Sideroxylon and Plumbago. The known flora totals 56 species.

Tortoises formerly existed at Cosmoledo, and Fryer reported finding their fossil eggs. Other reptiles include Phelsuma abbotti menaiensis, Hemidactylus mercatorius, and Ablepharus boutonii. 37 species of insects are recorded, and three species of land mollusca. There are three recorded resident land birds: Zosterops maderaspatana maderaspatana, Nectarinia sovimanga buchenorum, and Dryolimnas cuvieri. Abbott reported the existence of the rail from hearsay, and according to Fryer it existed in 1919 on South Island, though he did not land there and observe it. The breeding sea birds are Phäethon rubricauda rubricauda, Sula dactylatra melanops, Sula sula, Fregata minor, Sterna anaethetus, Sterna fuscata, and Anous stolidus pileatus. Large flocks of Egretta garzetta and small number of Dromas

ardeola have recently been recorded. Corvus albus is known and Cisticola cherina has been introduced. Both Ardea cinerea and Butorides striatus probably breed.

Guano deposits are found on North Island, and have been worked; there are reserves of 3,500 tons.

Maize and coconuts are grown. Dupont recorded rabbits in 1906. Apart from notes on sea birds there is no recent information on the biota of Cosmoledo, though the rail is thought to be extinct.

Main references: Baker 1963, 86-92; Dupont 1907, 8-12, Fryer 1911, 428-430; Vesey-FitzGerald 1942, 13-15; Watson, Zusi and Storer 1963.

Additional references: Connolly 1925; Ridgway 1895; Vesey-FitzGerald 1940; Vesey-FitzGerald 1941.

Maps: Admiralty Chart 718 (survey of 1878); individual islands mapped by Baker 1963, 87, 89, 91, 93.

5. FARQUHAR (JOAO DE NOVA) 10°10'S., 51°7'E.

Farquhar is an atoll 11.5 miles long and 6.5 miles wide, maximum dimensions, with two main islands (South Island, North Island) on the eastern rim, the small island of Goelette on the southeast side, and three small islets on the north. The lagoon is shallow and full of patches, except near the east rim, where there is a deeper basin with up to 6 fathoms and an entrance on the north side with 3-5 fathoms. Fryer reports some residual elevated reefrock, but according to Baker the islands are all sand cays and there is no elevated rock. Most of North Island is less than 10 feet above sea level, with dunes 5-50 feet high at the south end; South Island has dunes 50-70 feet high. Goelette is low and sandy.

Very little is known of the biota. Pemphis, Tournefortia, Scaevola, Casuarina and coconuts are the only plants recorded. According to Rothschild the giant tortoise formerly occurred here, but no supporting evidence is known for this. 63 species of insects are known. Among the sea birds Sula dactylatra melanops, Sterna sumatrana mathewsi, and Sterna fuscata breed on Goelette, and Sula sula rubripes on South Island. Anous tenuirostis tenuirostris is recorded roosting but not breeding. There is a single native land bird, Foudia madagascariensis, which is common. Gardiner states that the Barred Ground Dove Geopelia striata has been introduced and is common at the settlement on North Island (Grande Poste).

There are no commercial guano deposits, except for some phosphatic sandstone and guano on the two main islands, but according to Piggott mining has disturbed the breeding colonies of terns. There are settlements on both North and South Islands, and a jetty on the former.

Main references: Baker 1963, 80-85; Gardiner 1907, 142-145; Gardiner 1936, 432-433.

Additional references: Carpenter 1916; Cockerell 1912; Edmondson 1923; Fleutiaux 1923; Forel 1907; Fryer 1910; Fryer 1912; Gardiner 1906; Grouvelle 1913; Hampson 1920; Jordan 1939; Maulik 1931; Needham 1913; Scott 1912; Vesey-FitzGerald 1940; Vesey-FitzGerald 1950.

Maps: Admiralty Chart 718 (survey of 1878); Baker 1963, 81.

6. ST PIERRE 9°19'S., 50°43'E.

St Pierre is a circular uplifted atoll 0.75 miles in diameter, with an area of 417 acres, situated 270 miles east of Aldabra and 19 miles southwest of Providence. The coastal cliffs rise to 8-30 feet above sea-level, with no fringing reef, and the reefrock is deeply intersected by caves and crevices. Dunes 10 feet high are perched on the cliffs near blowholes. The centre of the island is close to sea-level, and has a small tidal pool. Physiographically the island resembles Assumption.

The native vegetation consisted of *Sporobolus* on the dunes; *Suriana* and *Tournefortia*, or *Pemphis*, along the lee coast; and a scrub of *Pemphis*, *Hibiscus*, *Pisonia* and *Euphorbia* over the rest of the island. Coppinger mentioned a dense growth of scrubby bushes and three or four palms in 1882. 25 species of land plants are recorded, and the flora was clearly like that of Aldabra and Assumption. Maize and tobacco have been grown.

The fauna formerly included the giant land tortoise, according to Rothschild, but no direct evidence of this has been found. Apart from the Madagascar fody, *Foudia madagascariensis*, there are no land birds, and though *Sula sula rubripes* formerly nested in large numbers, it does not do so now.

The ecology of the island has been drastically altered by the mining of guano and high grade phosphate rock, which began in 1906. Between 1926 and 1960, 151,000 tons were exported, and reserves of 10,000-15,000 tons remain. The island surface is now a "maze of pits and crevices as a result of guano working", according to Baker. The mining has resulted in almost total destruction of the vegetation. "On the east coast a few scattered specimens of *Pemphis* bushes still exist whilst only two extremely battered specimens of *Pisonia* have been left on the centre of the island. Of the herbs which survive on the remains of the soil, *Stachytarpheta indica* is the most common" (Piggott 1961). Piggott also records the introduction of *Gaillardia pulchella*; together with the following exotics near the settlement: *Datura stramonium*, *Asystasia gangetica*, *Agave* sp., *Carica papaya*, and *Musa* sp. *Casuarina* has been planted as a windbreak, and is doing well. The guano has continued to be worked, and a crushing plant has been installed.

Main references: Baker 1963, 100; Coppinger 1883, 236; Dupont 1907, 1-2; Gardiner 1907, 148-149; Gardiner 1936, 434-435; Piggott 1961; Vesey-FitzGerald 1941; Vesey-FitzGerald 1942, 15; Watson, Zusi and Storer 1963.

Map: Baker 1963, 100.

7. PROVIDENCE 9°14'S., 51°02'E.

Providence Island is situated at the north end of the 25 mile long, 6 mile wide Providence Bank. It is 2.75 miles long and 1200 yards wide, with a reef platform on the west side. The island is sandy, without elevated reefrock, and is covered with coconuts and *Casuarina*. 33 species of plants are recorded, mostly collected by Coppinger in 1882 and by Dupont. Coppinger also records the following cultivated plants: pawpaw, custard apple, pepper, sweet potato, onions, lettuce, and capsicum.

Very little is known of the fauna. Rothschild records the former existence of the giant land tortoise, but on unknown authority. Coppinger found seven

giant tortoise imported from Aldabra roaming in the woodland in 1882; and he also states that green turtle nest on the island in April. There are 22 recorded species of insects. There are no land birds. Sea birds breeding on the bank include Sterna bergii thalasseus, Gygis alba monte, and possibly Dromas ardeola. Shore birds breeding on the bank include Sterna bergii thalasseus, Gygis alba monte, and possibly Dromas ardeola. Shore birds breeding include Ardea cinerea, and Butorides striatus is recorded. There are also nine records of vagrants and migrants.

Guano reserves have been considerable, covering 147 acres at the north end of the island, out of a total area of 388 acres. Between 1935 and 1949 27,260 tons were exported, and Baker estimates reserves at 9,000 tons.

Cerf Islands (Banc du Sud), at the southern end of Providence Bank, is now a single large sand cay, with four smaller ones, while in 1905 there were seven small islands. Casuarina and Scaevola are recorded, and coconuts and cassava are said to be grown. Coppinger found only pioneer vegetation and bushes in 1882.

Main references: Baker 1963, 77-80; Coppinger 1883, 231-236; Gardiner 1907, 146-148; Gardiner 1936, 434-435; Watson, Zusi and Storer 1963.

Additional references: Butler 1884; Carpenter 1916; Coppinger 1884; Fryer 1911; Holland 1896; Linell 1897; Maulik 1931; Ridgway 1895; Schenkling 1922; Scott 1913; Warburton 1912.

Chapter 4

THE BIRDS OF ALDABRA AND THEIR STATUS

C. W. Benson

Department of Zoology, Cambridge University

1. HISTORICAL INTRODUCTION

Prior to 1892, the one and only piece of ornithological activity pertaining to Aldabra seems to have been the collecting by Commander Wharton, during the visit of H.M.S. Fawn to the atoll in July 1878, of two specimens of the rail Dryolimnas cuvieri aldabranus, described by Günther (1879). They are in the British Museum (Natural History). It is true that Sclater (1871) had described a turtledove as Turtur aldabranus from two specimens allegedly from Aldabra, but as will be shown their origin was almost certainly in the Amirante Islands. Although during the course of her voyage in 1881-82 H.M.S. Alert visited the Amirantes and Gloriosa, together with Providence, Cerf Islands, and St Pierre, she did not visit Aldabra or the nearby islands (Coppinger 1883; Coppinger and others 1884).

Dr W. L. Abbott spent three and a half months, from September to December 1892, on Aldabra, and made a thorough survey of the avifauna. His collections were sent to the Smithsonian Institution, United States National Museum. The new forms collected were described by Ridgway (1893, as amended 1894a; 1894b), certain nests and eggs by Bendire (1894), and finally Ridgway (1895) gave an account of Abbott's ornithological activities in the western Indian Ocean generally, quoting many field observations.

Dr A. Voeltzkow spent from 21 May to 21 June 1895 on Aldabra,[1] and collected 59 specimens, now in the Natur-Museum und Forschungs-Institut Senckenberg, Frankfurt. The collection was catalogued by Berlepsch (1899). Voeltzkow (1917, 457-459) himself drew up a list of Aldabra birds, but it provided no new information. The yacht Valhalla, on which M. J. Nicoll was naturalist, arrived at Aldabra on 13 March 1906, and stayed there three days. The birds collected were reported on by Nicoll (1906), and are in the British Museum. There is also a more general account of the visit by Nicoll (1908).

J. C. F. Fryer spent from August 1908 to February 1909 in the archipelago--that is, including Assumption, Cosmoledo and Astove as well as Aldabra. He wrote a general account of the visit, including notes on the flora and fauna (Fryer 1911). These notes contain few references to birds, none of which were apparently collected. But Fryer (1911, 399) states that a bird collector for the Tring Museum spent a year there. No general account of this collection has been traced. There are merely incidental references in the literature to particular species, as by Lowe (1924). Two collectors appear to have been involved, namely F. R. Mortimer and a gentleman named Thibault. The bulk of the collection must now be in the American Museum of Natural History, to whom in 1932 Lord Rothschild sold the majority of the birds in the Tring Museum. But a few specimens formed part of a Rothschild Bequest to the British Museum in 1939. Two other small collections in the British Museum from Aldabra include one of 26 specimens presented as a Howard Saunders Bequest, collected in October and November 1906, the collector's name unrecorded, and one of 12 specimens collected and presented by R. Dupont, of the Botanic Station, Seychelles, and also dated October 1906.

---

[1] Voeltzkow (1897, 42-43) says he arrived on Aldabra on 21 April 1895, and (1897, 55) that he stayed for over one month, but this cannot be reconciled with his specimen labels - Editor.

Dupont (1907) has given an account of his visit to the archipelago, which was primarily an agricultural reconnaissance, and which lasted from September 1906 to January 1907. Two paragraphs (Dupont 1907, 23) are devoted to birds, and appended is a bare list of species for various islands in the western Indian Ocean, Astove, Cosmoledo, Assumption and Aldabra all being shown separately. It is not stated what is the basis for this list, and it is not referred to in Section 3 below except in the case of those records which are unavailable in any other source of information.

I have no knowledge of any further ornithological activity until 1937, when L. D. E. F. Vesey-FitzGerald visited the Aldabra archipelago. Few specimens were collected, but for accounts of the land and sea birds respectively, see Vesey-FitzGerald (1940, 1941). Vesey-FitzGerald also obtained specimens of the sunbird Nectarinia sovimanga buchenorum from Cosmoledo in April 1952 (Williams 1953a).

In May 1954 the French ship Calypso visited Aldabra. Thirty-one birds were collected by G. Cherbonnier, between 10 and 26 May. The collection is now in the Muséum National d'Histoire Naturelle, Paris, and Dr G. Roux has kindly provided a list of the species and numbers of specimens of each. During 1959-64 there were several visits to Aldabra by British warships, and accounts have been published of the observations made. The first was by H.M.S. Leopard, in November 1959, for a brief account of which see Boulton (1960). In January 1962 a party from H.M.S. Owen spent three days ashore on Aldabra, the ship returning for twelve hours at the end of the next month (Morris 1963, as annotated by Bourne). In March 1964 H.M.S. Owen again visited Aldabra (and also Cosmoledo, Astove and Assumption). The observations made by the ship's personnel were written up by Bourne (1966).

The Bristol Seychelles Expedition 1964-65 spent part of November and December 1964 on Aldabra, as a result of which there are already several publications. There is a general account of the birds by Penny (1965), the expedition's leader. Dawson (1966a) has reported on the sea birds of the Seychelles generally, including also the Aldabra archipelago, while Gaymer (1966) has presented a case for the conservation of Aldabra. They caught, measured, weighed and released many land birds, the results of which Gaymer has been kind enough to place at my disposal. They also collected 19 specimens, which he has allowed me to use in the writing of this paper, and which are to be presented by the Expedition to the British Museum.

2. ACKNOWLEDGMENTS

Dr D. R. Stoddart, of the Department of Geography, Cambridge University, who invited me to write this paper, has readily responded to various requests for assistance. Dr W. R. P. Bourne has made available papers from Sea Swallow, examined various specimens with me in the British Museum, and criticised part of the original draft of this paper. As already mentioned, R. Gaymer has placed certain information and specimens which he collected at my disposal. I am most grateful for his generosity in these matters. I must also thank D. Goodwin for examining with me in the British Museum material of the turtledove Streptopelia picturata.

The specimens studied at first hand are mostly in the British Museum (Natural History), London, where J. D. Macdonald and his staff have provided every possible facility. I have also been fortunate to have had available at my place of employment, in the Department of Zoology, Cambridge University, a collection of over 1,000 specimens from the Malagasy Region (for a definition of which, see Section 3). It was assembled by Professor A. Newton, in charge of the Department from 1866 until his death in 1907, and his brother Sir Edward Newton, resident on Mauritius from 1859 to 1877. It includes a few of Abbott's Aldabra specimens, obtained in 1894 by exchange with the Smithsonian Institution.

In May 1966 I spent a week in the Muséum National d'Histoire Naturelle, Paris, in pursuance of a long-term study of the origins of the land avifauna of the Malagasy Region, and received all possible help from Drs J. Dorst, C. Jouanin and F. Roux. At this time I had no special interest in Aldabra, though I did take some note of a few of the specimens collected by Cherbonnier. As already recorded, Roux has now provided a complete list of them, and has moreover lent me several of particular interest.

Special thanks are due to Dr George E. Watson, of the Smithsonian Institution, who lent me at short notice by air mail a number of Abbott's specimens, including the complete skin of a flamingo. He has also quickly responded to inquiries about some other specimens. I am also most grateful to Dr J. Steinbacher for lending me some of Voeltzkow's specimens and for information about others.

Finally, I thank R. E. Moreau, W. R. P. Bourne, R. Gaymer and D. R. Stoddart for their comments on this paper.

3. SYSTEMATIC LIST

This list is divided into (1) land birds and (2) sea birds. The latter heading includes consideration of species occurring (or likely to occur) on Aldabra included in Alexander (1955). The land bird list is subdivided into (a) species which breed on Aldabra and may be presumed resident; (b) migrants, (i) already recorded, and (ii) not yet recorded but likely to occur; and (c) species whose status is still uncertain.

The term Malagasy Region is employed in the same sense as by Moreau (1964), and includes Madagascar, the Mascarene Islands (Réunion, Mauritius and Rodriguez), and other oceanic islands in the western Indian Ocean to as far north as the Seychelles. The term Aldabra archipelago includes Aldabra, Assumption, Cosmoledo and Astove, though not Gloriosa.

In general, the nomenclature, both scientific and English, follows that of Watson, Zusi and Storer (1963). Subspecific names are not used except where they seem to have been reasonably satisfactorily established. English names are the equivalent of scientific specific, rather than subspecific, names.

A sign "o" indicates an unsexed specimen. The average of measurements is often given in brackets following the extremes.

It should be well-known that Bergmann's Rule is to the effect that in warm-blooded vertebrates the smaller-sized geographic forms of a species are found in the warmer parts of the range, the larger-sized in the cooler parts of the range.

(1) Land Birds

(a) Breeding Residents (or presumed so)

Dawson (1966a, 7) records the Indian Reef Heron Demiegretta asha as breeding exclusively on Astove. But if this is so, it could also do so on Aldabra. However, in the absence of supporting details one cannot be convinced that it breeds even on Astove, especially as according to Watson, Zusi and Storer (1963, 24) it is not known to breed otherwise nearer to Astove than Ceylon. It may also be mentioned here that Vesey-FitzGerald (1940, 488) found the Madagascar Grass-Warbler Cisticola cherina abundant on Cosmoledo and Astove, though he did not see it on Aldabra. Unfortunately the specimen which he collected and sent to the British Museum cannot be traced.

Ardea cinerea cinerea Linnaeus   Grey Heron

According to Abbott (in Ridgway 1895, 530), this species breeds on Aldabra, and nests with young were seen in November. One specimen was collected, and likewise by Voeltzkow (Berlepsch 1899, 495). Nicoll (1906, 695) records it from both Aldabra and Assumption. Morris (1963) saw a few on Aldabra, but Bourne (1966) records "hundreds". Dupont (1907) lists it from throughout the archipelago.

Benson (1960a, 31) considers that two specimens from the Comoros are better placed with A. c. cinerea than A. c. firasa Hartert of Madagascar, the latter distinguishable by longer measurements for the culmen and tarsus (respectively 131 - 145 as against 110 - 133, and 185 - 200 as against 155 - 182 mm.). He thought that four immature specimens from Aldabra and Assumption were also best placed with A. c. cinerea, though possibly not fully grown. Berlepsch (1899, 495) gives the wing of Voeltzkow's specimen as 465, culmen 140, tarsus 165 mm. The tarsus measurement is well within the range of A. c. cinerea. That for the culmen agrees better with A. c firasa, but may have been taken from the base of the skull instead of the end of the frontal feathering as in Benson's measurements. A specimen in Cambridge from the Amirante Islands, collected in December 1864, has wing 424, culmen (from frontal feathering) 120, tarsus 170 mm., thus agreeing with A. c. cinerea. It is concluded that the populations frequenting all of the above-mentioned islands are best attributed to this subspecies, and are accordingly of African rather than Madagascan origin.

Butorides striatus crawfordi Nicoll   Little Green Heron

B. s. crawfordi, of which I have seen the type, an adult male in the British Museum from Assumption, and another adult male therein from Aldabra, can easily be distinguished from B. s. rhizophorae Salomonsen, of the Comoros, by the paler grey of the underside. I have also been lent the specimen collected by Abbott on Aldabra (Ridgway 1895, 531). It is a male in immature dress, and cannot be used in considering subspecific differences based on colour. The same applies to a female in Paris collected on Aldabra by Cherbonnier, which I have also seen. But all four specimens are smaller than

rhizophorae, see below. Presumably there is the same sexual colour difference in the adult of crawfordi as in rhizophorae and B. s javanicus (Horsfield), that is, the female has the sides of the neck, chest and abdomen washed with brown, and the spotting on the throat more strongly pronounced (Benson 1960a, 34).

Benson (1960a) gives the wing-length of 16 specimens of rhizophorae as 170 - 180 mm. Thirteen specimens in London, Paris and Cambridge from Reunion, Mauritius and Rodriguez, doubtfully separable from the Asiatic javanicus, measure 167 - 181 mm. On the other hand, 10 specimens from the Seychelles (Mahé, Cousin, Praslin, La Digue), attributable to B. s. degens Hartert, measure 159 - 168 mm. only. Like degens, crawfordi is also small, as the following figures show:

Adult ♂	159, 161 mm.
Immature ♂	159 mm.
Immature ♀	157 mm.

An immature male collected by Voeltzkow which I have been lent has wing 152 mm., and may not be quite fully grown. This certainly applies to an immature specimen in Cambridge from the Amirantes, with wing 140 mm. only.

Benson (1960a, 34) accepts the contention of White (1951, 460) that rhizophorae is of Asiatic origin, and there is no reason to suppose that this does not also apply to crawfordi. On the other hand, B. s. rutenbergi (Hartlaub) of Madagascar is very close to B. s. atricapillus (Afzelius) of Africa, whence White suggests that degens of the Seychelles is also derived.

Abbott (in Ridgway 1895, 531) found this species quite common on Aldabra, breeding among mangroves in November and December, laying two eggs. Probably the breeding season is fairly extensive, since in the Comoros Benson (1960a, 35) obtained data pointing to egg-laying in August and September. Abbott also noted that the birds stand for hours on the backs of turtles, catching the blue-bottle flies which swarm on the turtles' backs and heads. Dupont (1907) lists this species from throughout the archipelago.

Egretta garzetta dimorpha Hartert   Little Egret

E. dimorpha has often been regarded as a full species, as by Watson, Zusi and Storer (1963). However, I see no reason to differ from the opinion of Grant and Mackworth-Praed (1933) and Berlioz (1949, 20), for example, that dimorpha is conspecific with E. garzetta. Dimorpha inhabits Madagascar and the Aldabra archipelago, and is notable for the common occurrence of a dark blue-grey phase as well as a white phase. A grey phase also occurs in coastal eastern and north-eastern Africa and in coastal West Africa (White 1965, 25), but is rare or quite absent in the interior of Africa. Grant and Mackworth-Praed (1933) have separated the populations of Aldabra and Assumption as E. g. assumptionis, differing from dimorpha by its longer bill. This was on the basis of material in the British Museum. There is no further material available therein. While due note must be taken of this difference, the measurements presented show an appreciable overlap. On existing evidence it is difficult to justify recognition of assumptionis.

Abbott (in Ridgway 1895, 530, under Demigretta gularis) found this the commonest heron on Aldabra, and breeding in large numbers in December, laying from two to four eggs. The white phase was twice or thrice as numerous as the blue. Nicoll (1906, 696, 704, under Demiegretta sacra) collected it on both Assumption and Aldabra, finding it extremely abundant on the latter. A specimen collected on Aldabra was partially white and dark. I can confirm that this applies to both this and another specimen from Aldabra, both in the British Museum. Morris (1963) found both phases plentiful on Aldabra. Bourne (1966) records hundreds, of which about forty per cent were in the dark phase. He also records it from Cosmoledo, where the phases were about equal, while one "White-faced Heron" was seen on Astove (presumably this was a specimen of E. g. dimorpha in the dark phase, in which the chin and throat are still white). He gives no record from Assumption, and possibly it has been extirpated there. Dawson (1966a, 7) records large flocks on Cosmoledo, Astove and Aldabra, the proportion of light to dark birds being about seven to three, with the occasional intermediate piebald.

Milon (1959) found that in two breeding colonies in Madagascar selected for study the ratio of the dark phase to the white phase was about 35: 65. The observations from the Aldabra archipelago tend roughly to bear this out.

Threskiornis aethiopica abbotti (Ridgway) Sacred Ibis

This species occurs in Africa (T. a. aethiopica (Latham)), Madagascar (T. a. bernieri (Bonaparte)) and Aldabra (T. a. abbotti). The characters on which these three subspecies can be recognised may be summarised as follows (it should here be mentioned that immature specimens of all three have the head and neck feathered, whereas in adults these areas are bare):

Feathering on head and neck (in immature): In aethiopica and bernieri white heavily streaked black; in abbotti black streaking much reduced, and only on a few feathers. (Only one immature specimen of abbotti was available. But the difference was striking, and shows up well in three photographs in Nicoll (1908).)

Decomposed tertials: Glossy purplish slate in aethiopica, bluish slate in bernieri, much paler than in aethiopica; bluish slate in abbotti, as in bernieri, but darker.

Metallic green tips to remiges: Extending back 40 - 60 mm. in aethiopica; not more than 15 mm. in bernieri, in three out of eight specimens absent; not more than 10 mm. in abbotti, in four out of six specimens absent.

Iris (in adult): Brown in aethiopica (see for example McLachlan and Liversidge 1957); white in bernieri; bluish-white in abbotti. (The difference between bernieri and abbotti is as given by Ridgway 1895, 530, and is confirmed from the labels of one adult specimen of the former and two such of the latter. An immature specimen of abbotti had the iris very dark brown.)

Ridgway also suggests that the lower half of the neck is entirely naked in abbotti, but not so in bernieri. I cannot convince myself that the extent of feathering up the neck is not variable in the adult of all three subspecies, and that it can be used as a distinguishing character. Ridgway further suggests that the tips to the remiges differ in colour, but it seems that there is only a difference in its extent.

Presumably bernieri was derived from aethiopica, and probably abbotti from bernieri rather than aethiopica. The colour of the decomposed tertials, the reduction of the dark tips to the remiges, and the colour of the iris all suggest a closer relationship of abbotti to bernieri than to aethiopica.

The following are measurements in mm. of the material of bernieri and abbotti studied, in London, together with two specimens of bernieri in Cambridge:

	Wing			Culmen from base			Tarsus		
Bernieri									
Adult ♂	374			169			95		
Adult ♀ ♀	342	348	362	132	137	144	72	76	82
Immature ♂	357			182			84		
Immature ♀ ♀	334	340		136	143		74	78	
Immature ○	371			broken			87		
Abbotti									
Adult ♀ ♀	336	340		125	132		76	76	
Adult ○	335	337	338	125	133	136	70	70	72
Immature ♂	347			176			80		

These figures do not suggest any marked difference between the two subspecies. Evidently males are longer billed in both.

Falco newtoni aldabranus Grote   Madagascar Kestrel

It is presumed that Madagascar, inhabited by F. n. newtoni (Gurney), has been the source of origin for the populations elsewhere in the Malagasy Region, namely F. punctatus Temminck of Mauritius, F. n. aldabranus of Aldabra, and F. araea (Oberholser) of the Seychelles. A single unsexed specimen of aldabranus (judging from its wing-length) from Anjouan, in the Comoros, is considered by Benson (1960a, 39) to have been a stray from Aldabra, but is discussed further below. Failure to colonise the Comoros may be because the islands as a whole were probably originally almost wholly covered with evergreen forest (Moreau 1966, 346). In Madagascar, Rand (1936, 378) found the species everywhere except in heavy forest.

Benson (1960a, 39) studied to some extent the material in London. It has been re-examined, 13 specimens in Cambridge have also been considered, and wing-lengths taken of three specimens of aldabranus collected by Cherbonnier, in Paris. Material of F. araea in London, Paris and Cambridge has also been considered.

From field observations, Gaymer tells me that the male of F. n. aldabranus is more brightly coloured than the female. I cannot make any personal judgment in this matter, since the only two specimens examined after I had

had my attention drawn to this possibility are two immature ones in the British Museum. There is no marked colour difference in F. n. newtoni. Possibly, considering adults, the female has the mantle devoid of any markings, whereas the male has a few spots. But the difference is not well defined, and the male is certainly no brighter than the female. Immature specimens have the whole upperside rufous, heavily barred with black on the mantle and wing-coverts. In adults the markings are in the form of spots, and relatively sparse. Grey is only apparent in the immature birds on the tail, and even in that area there is some rufous admixture. Adults also have the rump grey, and there is some grey admixture on the crown. On the underside there is no marked difference, but regardless of age or sex there is clearly dimorphism, specimens being either white or chestnut. But the only evidence of a chestnut phase in aldabranus is from the specimen labelled Anjouan, which is immature, and is this colour below. But a female of aldabranus collected by Nicoll, also immature, is white below, as are three males and two females collected by Abbott, as Watson informs me. A coloured photograph of a bird taken by Gaymer also shows a white underside. Unfortunately I did not take note of the colour in the three specimens in Paris, but on present evidence there is no certainty of the existence on Aldabra of a morph with underside chestnut (it should be a simple matter to check on this by field-observations, not necessarily accompanied by collecting). Apart from this, I am not satisfied that any other colour-differences exist between aldabranus and nominate newtoni. There is no suggestion of it from the two immature specimens in the British Museum. Actually it is possible that the Anjouan specimen, in view of its chestnut underside, is an unusually small example of nominate newtoni (its wing-length is 176 mm., see Table 5), and so a stray from Madagascar.

The wing-lengths in Table 5 show that in both newtoni and araea of the Seychelles, females average larger than males, though with an overlap. Considering the sexes separately, it is evident that, although there is some overlap, aldabranus does average considerably smaller than nominate newtoni. This would appear to be a Bergmann's Rule effect, and it will be seen that this has been much accentuated in araea. Araea could well be regarded as conspecific with newtoni. The most marked difference from newtoni is that in adults the crown is unstreaked, plain grey, and the underside unmarked, plain pinkish, showing no dimorphism.

Nicoll's female of aldabranus has the colour of the iris recorded on the label as yellow, which he emphasises (1906, 701) as being unusual. Yet Watson tells me that in all five of Abbott's specimens it is recorded as brown or dark brown. On only seven of the specimens of nominate newtoni is there any record of the colour. In six it is given as hazel or brown, though in the seventh as "jaune" (yellow). Conceivably the colour could change with age. One of these six specimens was collected with six eggs (see also below), and so presumably fully adult. A coloured photograph taken by Gaymer of an apparent adult aldabranus also shows a brown iris. Yet so also does the one of nestlings in Penny (1965). An error may somehow have arisen in ever recording the iris as yellow. A yellow iris should show up in life, and Gaymer tells me that he has no note of it. In F. tinnunculus, from which newtoni is presumably derived, the iris is apparently always brown (see for example Witherby and others 1941, 31; and McLachlan and Liversidge 1957, 65). In four adults of F. araea

Table 5. Wing-lengths (in mm.) of specimens of Falco newtoni and F. araea

F. n. newtoni, MADAGASCAR			
19 ♂♂ 177 - 196 (185.8)	14 ♀♀ 188 - 210 (196.6)	42	177 - 211 (192.5)
F. n. aldabranus, ALDABRA			
4 ♂♂ 170 170 175 183	3 ♀♀ 186 188 197	4	170 174 176 177
F. araea, SEYCHELLES			
9 ♂♂ 142 - 152 (147.0)	7 ♀♀ 151 - 155 (153.1)	6	143 - 157 (150.3)

Notes: Some sexed specimens have been relegated to the unsexed column, if the sexing seemed not beyond reasonable doubt.

The number of sexed specimens of F. n. newtoni shows an increase on those in Benson (1960a, 40). This is based mainly on specimens sexed by E. Newton, considered reliable.

First male figure of F. n. aldabranus from Berlepsch (1899, 492), first female from specimen in British Museum. Remainder of figures of sexed specimens supplied by Dr G. E. Watson from material in the Smithsonian Institution. Of the four unsexed specimens, the figure 176 is for the Anjouan bird, but the remainder from material in Paris. The smallest is unsexed as females, but perhaps incorrectly.

in Cambridge it is recorded as brown, likewise in five of punctatus. It should be simple to settle this question by field-observation.

Rand (1936, 379) records copulation in Madagascar in September. Newton (1863, 336) records a nest with five eggs on 17 September, the female parent of which is in Cambridge. Another female in Cambridge was collected at Tananarive on 17 September from six eggs. It may be expected that in Aldabra too F. newtoni breeds predominantly in the hot pre-rains season. The record by Penny (1965) is in keeping with this. The precise date of the taking of the photograph of the three nestlings was 18 November, so I am informed. Note also the apparent reduction in clutch-size compared with Madagascar.

Dryolimnas cuvieri aldabranus (Gunther) White-throated Rail

The genus Dryolimnas is endemic to the Malagasy Region. D. c. cuvieri (Pucheran) occurs in Madagascar, and is said to have also formerly been resident on Mauritius (Rountree and others 1952, 180). At one time the species was apparently represented on all four islands of the Aldabra archipelago, though Vesey-FitzGerald (1940, 487) reported that it was extinct except on Aldabra. As regards Cosmoledo and Astove, which Abbott did not visit, he had it at second-hand that rails swarmed on both islands (Ridgway 1895, 529). Dupont (1907, 13, 43) indicates that in late 1906 D. c. abbotti still existed on Assumption but was extinct on Cosmoledo and Astove. However, Fryer (1911, 428) saw what he presumed to be this form on Astove in 1908, and he reported (1911, 430) its existence on South Island of Cosmoledo, though he did not land there. Evidently it finally became extinct on these two islands some time

between 1908 and 1937, when Vesey-FitzGerald visited the archipelago. D. c. abbotti (Ridgway), of Assumption, was originally discovered by Abbott in 1892. It still flourished in 1906, Nicoll (1906, 695) finding it one of the most abundant birds on the island, allowing approach to within a few inches. However, he (1908, 111) predicted its extirpation due to imported rats, which were very abundant and probably ate many eggs. According to Fryer (1911, 433), it still existed in 1908, but like the Cosmoledo and Astove populations evidently became extinct between 1908 and 1937. On Aldabra in 1892, Abbott (in Ridgway 1895, 528) found R. c. aldabranus very common on all the islets except South Island, where it had been exterminated by the cats which ran wild there. Yet in 1906, Nicoll (1906, 702; 1908, 117) in the course of his three-day visit saw only two. According to Gaymer (1966), a few hundred survive only on Middle Island, though Bourne (1966) mentions that it was twice seen on Polymnie. Its extirpation elsewhere on the atoll is probably due to cats. The species is unknown from any other island in the Malagasy Region. It may have failed to colonise the Comoros due to a lack of sufficient marshy habitat, such as it mainly frequents in Madagascar (Rand 1936, 357).

Abbotti differs from nominate cuvieri in being paler, more greyish olive above, with the streaks narrower. It also has the white on the chin and throat more extensive, tending to extend onto the uppr chest, while the white barring on the lower abdomen is broader and coarser. Aldabranus was described first by Günther in 1879 from two specimens, in the British Museum, collected by Commander Wharton. This subspecies is slightly more yellowish olive above than in nominate cuvieri, while the streaking tends to be finer, and in three specimens is virtually obsolete. The extent of white on the chin and throat is variable. The white barring on the lower abdomen is relatively fine, as in nominate cuvieri. In all three subspecies the immature bird is dingy olive on the whole upperside. The cinnamon coloration of the adult, on the crown, nape and sides of head, as well as on the chest and upper abdomen, is lacking, and these latter two areas are dull brown. The single immature of aldabranus available differs from one such of abbotti and several of nominate cuvieri, in having the white feathers of the chin and throat tipped with rufous.

Measurements of the three subspecies are given in Table 6. It will be seen that aldabranus is much the shortest winged, and according to Abbott (in Ridgway 1895, 529) it has almost completely lost the power of flight, though Fryer (1911, 418) states that it can "flutter along". Even the extinct abbotti was considerably shorter winged than nominate cuvieri, in process of losing the power of flight. Nicoll (1908, 109) states that he never saw one fly. On average, aldabranus is longer billed than the other two subspecies, and aldabranus and abbotti have a shorter tarsus and middle to e than nominate cuvieri.

Alectroenas sganzini minor Berlepsch   Comoro Blue Pigeon

This genus is confined to the Malagasy Region, and four species have been distinguished:

A. nitidissima (Scopoli): Mauritius, extinct since about 1830.
A. madagascariensis (Linnaeus): Madagascar.

Table 6. Measurements (in mm.) of specimens of Dryolimnas cuvieri

Specimens	Wing	Culmen from base	Tarsus	Middle toe with claw
MADAGASCAR (D. c. cuvieri)				
♂♂	147 151 152 155 157 158 160	41 43 45 45 45 46 46	41 42 43 44 44 45 46	48 49 50 50 51 51 54 54
♀♀	142 143 144 145 145 147 147 148 150 150 151 162	38 38 39 39 40 40 41 41 41 41 41 45	40 40 40 41 41 42 43 43 44 45 45 46	45 46 47 48 48 49 50 50 50 51 51
○○	146 147 148 148 149 151 152 155 159 160 160 160	38 39 39 39 40 40 40 43 45 45 46 47 47 48	39 43 43 43 44 45 45 46 46 47 47 50 50	44 46 47 49 49 49 50 52 52 52 53 54 55 56
Overall	142 - 162 (151.3)	38 - 48 (42.2)	39 - 50 (43.8)	44 - 56 (50.0)
ASSUMPTION (D. c. abbotti)				
♂♂	133 136 141	40 42 45 45	39 39 39 41	46 46 48
♀	136	41	39	42
Overall	133 - 141 (136.5)	40 - 45 (42.6)	39 - 41 (39.4)	42 - 48 (45.5)
ALDABRA (D. c. aldabranus)				
♂	127	48	41	46
♀♀	116 121 122 125	42 44 46 49	36 38 38 41	41 41 44 45
○○	115 117 122 123 126	44 46 46 49 50	37 38 40 41 41	43 44 46 48
Overall	115 - 127 (121.4)	42 50 (46.4)	36 41 (39.1)	41 - 48 (44.2)

Notes: The numbers of measurements do not tally completely in some series, because it was not possible to take all four measurements of some specimens. Thus there were four males of D. c. abbotti, but the wings and middle toes of one were incomplete. Some specimens may have been mis-sexed; for example the female of D. c. cuvieri with the longest wing.

A. sganzini (Bonaparte): Comoros and Aldabra.
A. pulcherrima (Scopoli): Seychelles.

In colour of plumage, *A. sganzini* is distinguished from *madagascariensis* by a blue instead of a mainly red tail and upper tail-coverts, and white instead of blue head, nape and chest. In *pulcherrima* the crown is red, and the remainder of the head, and the nape and chest, are bluish white rather than white as in *sganzini*. *A. s. minor* Berlepsch, confined to Aldabra, unknown elsewhere in the archipelago, was presumably derived from the Comoros rather than the reverse. In colour of plumage it does not differ from *A. s. sganzini*, though Benson (1960a, 51) did note that four Comoro specimens of nominate *sganzini*, from Mayotte and Moheli, had traces of red on the tail. Eight out of ten specimens of *minor* specially examined for this character show traces of it, either on the tail or the upper tail-coverts, or both. This tendency serves to emphasise the close relationship of *sganzini* to *madagascariensis*.

Gaymer had recorded the soft parts of three males of *minor* as follows: iris scarlet with golden inner rim; bare skin around eye bright crimson; bill waxy green, blue at base; feet pale blue. This description suggests no difference except in minor detail from nominate *sganzini* (see Benson 1960a). He also thought some feathers of the neck had pink tips.

Benson gives the wing-length of seven specimens of *minor* as 152 - 158, as against 163 - 184 mm. in 51 specimens of nominate *sganzini*. The small size of *minor* is fully borne out by the measurements of further material, using the three males collected by Gaymer, two specimens in Paris, and two recorded by Berlepsch (1899, 493): ♂♂, 148, 153, 154, 158, 159; ♀♀, 153, 154 mm. Gaymer gives the weight of his three males as 119.5, 120, 160 gms.

By analogy with the case of *Falco newtoni* and *araea*, it might be expected that *pulcherrima* of the Seychelles would be still smaller than *A. s. minor*. However, the following are wing-lengths of the material of *pulcherrima* in London, Paris, and Cambridge, showing that it is intermediate in size between nominate *sganzini* and *minor*: ♂♂, 162, 163, 168, 171; 8♀♀, 158 - 165 (160.9); 13 oo, 157 - 171 (162.9) mm.

Streptopelia picturata coppingeri (Sharpe) Madagascar Turtledove

This species is endemic to the Malagasy Region, if Diego Garcia is included. Benson (1960a, 47) discussed the subspecies to some extent, except for *S. p. chuni* (Reichenow), of Diego Garcia, of which no material was available, as has still been the case. This subspecies is not considered in the discussion which follows. It must suffice to say that according to the original description it is a dark edition of *S. p. picturata* (Temminck), of Madagascar, and, like it, is distinguished by having a grey head.

Thanks to (a) a loan of three of Abbott's specimens from Aldabra and another from the Amirantes, and of all five collected by Voeltzkow on Aldabra, and (b) the material in Cambridge and two Aldabra specimens collected by Gaymer, it is now possible to present a more comprehensive assessment. In the first place, the point must be emphasised, of which Benson (1960a) did not take note, that males tend to have the reddish purple on the upperside more

extensive than in females, and average larger (see the figures in Table 7). The only subspecies studied in which I have been unable to satisfy myself that this necessarily applies is S. p. rostrata (Bonaparte), of the Seychelles.

S. p. picturata, of Madagascar, is distinguishable from all the other subspecies considered by its bluish grey instead of purple head. S. p. comorensis (Newton), of the Comoros, has the reddish purple on the upperside as in nominate picturata, in males extending well onto the mantle and wing-coverts, in females more restricted, absent from the lower mantle. All of the material shown in the table from Gloriosa, Assumption and Aldabra is easily distinguished from both these other two subspecies in having the reddish purple on the upperside paler, more restricted, in males not extending beyond the upper mantle and lesser wing-coverts, in females not beyond the nape, absent from all the wing-coverts. Furthermore, the posterior of the upperside, where reddish-purple is lacking, is a much paler brown. This material is also paler below, with a pinkish rather than a purplish suffusion, which, unlike the upperside, tends to be more, not less, extensive onto the abdomen, which in nominate picturata and comorensis is grey or buffy white without any purplish suffusion. These differences may be a reflection of a relatively dry environment in the Aldabra archipelago and on Gloriosa.

Another type of variation is that, regardless of sex, in nominate picturata and comorensis there is usually some suffusion of grey on the rump and upper tail-coverts, in some specimens covering the whole of these two areas. But there was no sign of it in the Gloriosa and Assumption specimens, and it was only slightly apparent in two out of the 13 from Aldabra which had been personally examined.

The situation is complicated in that the two syntypes of S. p. aldabrana (Sclater), a male and a female in Cambridge, do not show the colour characters of the Gloriosa, Assumption and Aldabra material. On the contrary they agree quite well in colour with comorensis, and with a female lent to me collected by Abbott on Ile Alphonse, in the Amirantes. Dr Watson tells me that the latter differs from the type of S. p. saturata (Ridgway), a male from Ile Poivre, in the Amirantes, in having the reddish purple on the upperside a little less extensive. This would seem to represent the sexual difference to be expected, and is also noticeable in the two syntypes of aldabrana. With regard to the colour of the rump and upper tail-coverts, grey is well developed in the male syntype, but absent in the female and in the Ile Alphonse specimen. It is evident from their labels, in E. Newton's handwriting, that the two syntypes died in the captivity of the Zoological Society, London, the male of 17 January 1873, the female on 29 September 1871. Both had been bred in Mauritius. There is no indication by Newton on the labels, nor in the original register of the collection from the Malagasy Region in Cambridge made out by Professor Newton, that either specimen came from Aldabra, though Sclater (1871, 692) states that he had been informed by E. Newton that "these Doves were procured for him by Mr Swinburne Ward, when he visited the coral-reef of Aldabra in 1868". Presumably Newton meant the parents of the two specimens, in view of his statement on the labels that they were bred in Mauritius.

Either the two syntypes of aldabrana acquired a richer coloration in the course of captivity or their source of origin was not Aldabra but the Amirantes. The latter explanation seems the more likely, and they are placed accordingly

in the table, together with the female collected by Abbott on Ile Alphonse, which has wing 161 mm. The female syntype of aldabrana measures 142 mm. only, but its wings are incomplete. It is evident that these three specimens are much smaller than those from the Comoros, and this is the only really appreciable difference.

Obviously it would be confusing to use the name aldabrana for the Amirante birds. It would seem best to apply to the International Commission of Zoological Nomenclature for the annulment of the name Turtur aldabranus Sclater (1871), under article 79 of the International Code (1961), and to continue to use the name Turtur saturatus Ridgway (1893). In anticipation of this action and its subsequent approval, this is duly observed here. The Gloriosa, Assumption and Aldabra material seems all similar in colour, and the only difference is that that from Aldabra is slightly smaller, as the figures in Table 7 show. This is of no great import, and rather than introduce a new name it would seem best, at least on the basis of the material at present available, to apply the name S. p. coppingeri (Sharpe), with S. c. assumptionis (Nicoll) as a synonym, to the populations of all three islands, and not to introduce a new name for the smaller Aldabra population.

It will be seen from Table 7 that the Aldabra population of coppingeri, and saturata, are smaller than nominate picturata and comorensis, while rostrata is smaller still, probably a reflection of Bergmann's Rule. Rostrata is also quite distinct in colour. The posterior of the upper side is darker brown than in any of the other subspecies discussed, and the abdomen is markedly grey. This tendency to greyness is apparent in some specimens even on the throat and chest, and there is always some sign of greyish wash on the rump and upper tail-coverts. Also, viewed from above, the dark colouring in the tail appears as slate rather than brown. According to Loustau-Lalanne (1962, 17) rostrata has been largely replaced by nominate picturata, introduced about the beginning of the century. Actually there is a specimen of nominate picturata in Cambridge from somewhere in the Seychelles dated as long ago as 1870.

Gaymer gives the weight of a male collected by him as 165, and of a female as 170 gms. Another male, not retained, had wing 162 mm., and weighed as much as 187 gms. The soft parts he gives in both sexes as bill blue-grey, base pinkish-purple; legs and feet deep pink in front, blue-grey behind; iris brown, inner rim yellow. These descriptions agree with those by Benson (1960a, 47) for comorensis, except in the colour of the iris, which Benson records as reddish purple, inner rim yellow, but on Grand Comoro as entirely pale red or chestnut. Of four specimens collected by Nicoll on Assumption, in only one, a male, is the colour of the iris recorded, as yellow. In the specimen from Gloriosa, a female, it is given as orange-red. A male of rostrata from Ile Cousin had an orange iris. On the face of it the variation in the colour of the iris is considerable.

Finally, Dupont (1907), who is certainly confused in his nomenclature, lists Turtur aldabranus from Aldabra only, stating that it is extinct. He lists T. saturatus from throughout the archipelago (and also from the Seychelles, the Amirantes, Providence, and Gloriosa), and states (1907, 23) that on Aldabra it is "being used as an article of food and there is some chance of this being destroyed entirely". There is no other evidence of the existence of Streptopelia picturata on Cosmoledo or Astove, nor any satisfactory evidence that any form

has existed on Aldabra in the past one hundred years other than a small-sized population of *S. p. coppingeri*, which I have no reason to believe is not still flourishing. Incidentally, *S. p. coppingeri* on Gloriosa is the only example of a subspecific difference between that island and Madagascar.

Centropus toulou insularis Ridgway   Madagascar Coucal

This species is only known in the Malagasy Region from Madagascar (*C. t. toulou* (Müller)), Assumption (*C. t. assumptionis* Nicoll), and Aldabra (*C. t. insularis*). There are other related forms, often regarded as conspecific with *C. toulou*, in Africa and Asia. But *assumptionis* and *insularis* are barely separable from nominate *toulou*, and there can be no doubt but that Assumption and Aldabra were colonised from Madagascar. Moreau (1966, 347) remarks that the poor powers of flight of this species suggest that it used the Comoros as intermediate stages in its expansion and that there is nothing in the ecology of the Comoros to suggest that they would be unsuitable for the bird. As he (1966, 346) states, evergreen forest probably covered almost the whole of the islands originally. Rand (1936, 399) gives the habitat of *C. toulou* in Madagascar as "the ground-cover in the forest, occasionally in the trees, commonly in the brushlands and the dense reeds and grass of the smaller marshes". I am doubtful if the Comoros have ever been well suited to it. They could have been used as an intermediate stage, though an alternative route seems to exist via Gloriosa, Astove and Cosmoledo.

Watson, Zusi and Storer (1963, 78) indicate that the female is at all seasons mostly brown streaked with cream; the non-breeding male resembling the female, but acquiring a black head, body and tail for the breeding season. The evidence from the available material is that there is no sexual colour-dimorphism, but that both sexes in the breeding season have the head, mantle and chest black (with a marked bluish gloss in fresh dress), replaced in the off-season by dark brown feathers with pale buffy shaft-streaks. Also, the bill is black when breeding, otherwise brown. The only difference between the sexes at any season is that the female is larger (see the figures in Table 8). As Rand (1936, 400) points out, in Madagascar the breeding dress is worn from about October to March, and I have no reason to disagree. Material from Assumption and Aldabra also supports this. Two males of *assumptionis* collected by Nicoll on 12 March are still in breeding dress. One of them was collected at its nest with two eggs (Nicoll 1906, 694). Another collected by Abbott on 18 September, in Cambridge, has the moult into breeding dress almost complete. A male of *insularis* collected by Gaymer on 1 December is in full breeding dress, as is a female collected by Nicoll on 14 March. Nicoll also obtained an immature female on the same date, evidently not fully grown, see the measurements in Table 8. It has the crown and nape black, with a buffy spot near the tip of each feather. The throat and chest are barred dark brown and buffy, and the chestnut of the remiges and their coverts is heavily barred with dark brown. Similar young birds have been examined from Madagascar. A female of *insularis* dated October 1960, in the British Museum, is still in non-breeding dress, and differs from specimens of nominate *toulou* in this dress, which have the whole abdomen black, by having black restricted to the thighs and under tail-coverts, the feathers of the remainder of this area being buffy white, with some eight narrow

Table 7. Wing-lengths (in mm.) of material of Streptopelia picturata

S. p. picturata						
MADAGASCAR	12 ♂♂	165 - 177 (172.5)	14 ♀♀	158 - 170 (166.7)		
S. p. comorensis						
COMORO ISLANDS	14 ♂♂	174 - 183 (177.9)	15 ♀♀	166 - 174 (169.6)		
S. p. coppingeri						
GLORIOSA	♂	nil	2 ♀♀	168 169		
ASSUMPTION	2 ♂♂	172 173	2 ♀♀	167 171		
ALDABRA	6 ♂♂	163 - 171 (167.3)	7 ♀♀	155 - 166 (159.9	1 ○	171
S. p. saturata						
AMIRANTE ISLANDS	2 ♂♂	164 166	3 ♀♀	142+161 163		
S. p. rostrata						
SEYCHELLES	5 ♂♂	146 - 155 (149.2)	2 ♀♀	146 147	6 ○○	148 - 160 (151.3)

Notes: The nomenclature of the subspecies is explained in the text. The figures for S. p. rostrata include three specimens in Paris. The sources for the remainder of the figures, for the subspecies as a whole, are recorded in the text, with the addition of figures supplied by Dr G. E. Watson, from further material collected by Abbott in the Smithsonian Institution, consisting of one female from Gloriosa, one unsexed specimen (presumably a male) from Aldabra, and from the Amirantes a male from Ile Poivre (type of saturata) and a female from Ile Alphonse.

Table 8. Measurements (in mm.) of specimens of Centropus toulou from Malagasy Region

Specimens	Wing	Tail	Culmen from base	Tarsus	Long foretoe with claw
MADAGASCAR (_C. t. toulou_)					
18 ♂♂	140 - 160 (149.1)	198 - 227 (216.2)	27 - 30 (28.4)	37 - 41.5 (38.9)	33.5 - 39 (36.0)
15 ♀♀	158 - 176 (166.5)	224 - 256 (240.7)	29 - 33 (30.8)	39 - 44 (42.2)	36 - 41 (38.8)
ASSUMPTION (_C. t. assumptionis_)					
♂♂	149 150 154 155	219 222 226 237	25 28.5 28.5 29	37 38.5 39	36 37 38.5
ALDABRA (_C. t. insularis_)					
♂♂	153 154 159	240 242 256	24+28 28	36.5	36.5
♀♀	170 174 178 184	254 261 263 265	29 30 30.5 32	38.5 41	39 39
imm. ♀	159	203	30	37	40
o	166	199+	30	40	33

Notes: Only measurements of sexed, apparently adult, specimens included, except for the last two under _insularis_. Extra measurements (of wing, tail, culmen only) of _assumptionis_ and _insularis_ were supplied by Dr G. E. Watson from material in the Smithsonian Institution. No female of _C. t. assumptionis_ has been available.

bars of dusky on each. However, an unsexed specimen collected by Cherbonnier in May, which I have been lent, and also in nonbreeding dress, agrees better with nominate toulou.

There does not appear to be any definite colour-difference between the three populations. Nicoll (1906, 694) states that assumptionis differs from insularis by its smaller size and by being darker on the wings and mantle. The difference in size is that between males and females. That in colour would appear to be due to the fact that the adult female of insularis which he collected has the wing-coverts very worn, so that the chestnut has become unusually pale.

Insularis seems only to be separable from nominate toulou by its longer tail, while wing-lengths average longer. It should be emphasised that all tails measured were considered complete, the only doubtful one in this respect being the unsexed specimen of insularis shown separately in Table 8. Assumptionis is intermediate in tail length. Its validity is dubious, and it is possible that it no longer exists (Vesey-FitzGerald 1940, 487, saw one bird on Assumption in 1937).

Finally, the following particulars may be given here for the male of insularis collected by Gaymer on 1 December: bill black; legs steel grey; feet steel grey, lighter beneath; iris scarlet with navy blue outer rim; weight 120 gms.

Tyto alba affinis (Blyth) Barn Owl

This owl was introduced into the Seychelles from Africa some fifteen years ago, for an account of the disastrous effects of which, see Blackman (1965). The species is only otherwise known in the Malagasy Region from Madagascar, the Comoros and Aldabra. The name T. a. hypermetra Grote is sometimes used for these populations. But the only difference from African T. a. affinis is average larger size, as illustrated by wing-lengths. There is so much overlap in this respect that there is no justification for separating hypermetra from affinis (Benson 1960a, 59). Benson (1963a) has discussed five specimens from Aldabra, which show this average tendency to large size, like material from Madagascar and the Comoros. Aldabra was probably colonised via the latter.

Abbott (in Ridgway 1895, 533) found it rather common on Aldabra, and occasionally saw it in the daytime. It is curious that, apart from one specimen collected in 1906 (Benson 1963a), there is no subsequent record. However, it presumably still exists on Aldabra, as a breeding resident, but has been overlooked.

Caprimulgus madagascariensis aldabrensis Ridgway Madagascar Nightjar

This species is only known outside Madagascar from Aldabra, and the only other representative of the Caprimulgidae in the Malagasy Region is C. enerratus, confined to Madagascar. Enerratus inhabits heavy forest, madagascariensis more open country (Rand 1936, 411-412). As with Falco newtoni, C. madagascariensis may not have been able to colonise the Comoros because in the past they were too heavily forested.

The only specimen of C. m. aldabrensis Ridgway (1894, 373) personally examined, a female in Cambridge, is distinguishable from a long series of nominate madagascariensis by its paler, more greyish white crown and

scapulars, a lack of buffy spots on the foreneck, more extensive white in the tail, and larger size. Indeed it closely bears out Ridgway's original diagnosis. The following are wing-lengths in mm. of the two subspecies:

Aldabrensis

1 ♂	(160)	4 ♀♀	(153) 165 167 171

Madagascariensis

27 ♂♂	147 - 163 (154.9)	28 ♀♀	147 - 160 (153.6)

Except for the Cambridge specimen, the measurements of aldabrensis were supplied by Dr Watson from material in the Smithsonian Institution. He points out that in the case of the two bracketed figures, the specimens have the outer primaries worn, and this probably accounts for their shortness. The figures as a whole show a tendency to large size in Aldabra. Yet in the case of Falco newtoni and some other species the opposite applies, apparently in accordance with Bergmann's Rule. Possibly in this nightjar case there is an incipient tendency to the gigantism of which there are instances in the avifauna of the Gulf of Guinea Islands (Moreau 1966, 318-326), and of which Copsychus sechellarum Newton may be an example from the Seychelles, in comparison with the Asiatic C. saularis or the Madagascar C. albospecularis (Benson, in preparation).

In material of C. m. madagascariensis there is some sexual difference in colour. The male is rather darker above, with the white tips on the two outer pairs of rectrices more extensive, extending back for about 30 mm., as against 20 mm. in the female. Also the male has the spots on the four outer primaries white instead of rufous buff. The female of aldabrensis in Cambridge has white extending back on the two outermost pairs of rectrices for about 25 mm., and there is also some on the next pair, extending for about 15 mm. In the relative pallor of the upperside as a whole, and the presence of rufous buff on the primaries, it bears out the characters of females of madagascariensis, and presumably in aldabrensis there is a similar sexual dimorphism.

Hypsipetes madagascariensis rostratus (Ridgway)   Madagascar Bulbul

This is typically an Asiatic genus, unknown in the present time in Africa. Moreau (1966, 331) has discussed the curious situation in the Malagasy Region. H. madagascariensis, of southern Asia, also occurs in Madagascar, the Comoros, and on Gloriosa and Aldabra. Yet the Seychelles, geographically intermediate, are inhabited by another, larger, species, H. crassirostris, which also occurs on Moheli, in the Comoros, alongside madagascariensis (Moreau 1966, 365). Yet another large species, H. borbonicus, inhabits Mauritius and Réunion.

Benson (1960a, 67), using the generic name Microscelis, found that the populations of the Comoros were rather doubtfully separable from H. m. madagascariensis (Müller) of Madagascar, though he nevertheless retained the name H. m. parvirostris Milne-Edwards and Oustalet for them. He doubted

whether the Aldabra and Gloriosa populations were separable from parvirostris. However, Rand (1960, 296) recognises not only parvirostris but also H. m. grotei (Friedmann) for Gloriosa and rostratus for Aldabra.

Previously I was able to examine only four specimens from Aldabra, three of which were in very worn plumage. I have now had in addition a specimen in Cambridge, three on loan collected by Voeltzkow, and four collected by Gaymer. Rostratus is separable from nominate madagascariensis and parvirostris in being somewhat more brownish in tone on the upperside and thighs. Still only the one specimen from Gloriosa has been available, judging from which the population of this island is inseparable from nominate madagascariensis. The difficulty in separating the Malagasy forms of this species must be emphasised. Thus Moreau (1966, 349) is doubtful whether the Comoro and Madagascar birds are separable. On the face of it, colonisation of these islands north of Madagascar has been very recent. Aldabra may have been colonised from the Comoros rather than via Astove, Cosmoledo and Assumption, where the species is unknown.

Measurements in mm. of the 12 Aldabra specimens which have now been available may be summarised as follows:

Wing		Tail		Culmen from base	
103 - 115	(108.3)	*88 - 99	(93.2)	21 - 25	(23.2)

*Smallest figure in Benson (1960a, 67) omitted, tail incomplete.

These figures show no substantial difference from those provided by Benson (1960a, 67) for other islands.

The four specimens collected by Gaymer, all males, weighed 41, 41, 42, 46 gms. He has provided the following further figures for 19 other specimens mist-netted and subsequently released: wing 102 - 114 (107.9) mm.; tail 87 - 100 (94.0); culmen (exposed part) 18 - 21 (19.8) mm.; tarsus 18 - 27 (22.7) mm.; weight 35 - 48 (41.1) gms. He records the bill as orange, dark at tip, black nares; legs and feet brown; iris mid-brown. There is no substantial difference between this description and that by Benson (1960a, 67) for the soft parts of the Comoro specimens.

Dicrurus aldabranus Ridgway   Aldabra Drongo

D. adsimilis (Bechstein) is very widespread in Africa, while the closely allied D. forficatus (Linnaeus) inhabits Madagascar and Anjouan, in the Comoros. D. fuscipennis (Milne-Edwards and Oustalet), of Grand Comoro, may have been derived directly from adsimilis, as was possibly also D. waldeni Schlegel, of Mayotte, though in the shape of the tail it resembles the Asiatic D. macrocercus (Vieillot) (see Vaurie 1949, 221, 234).

Elsewhere in the Malagasy Region, the only representative of the Dicruridae is D. aldabranus, confined to Aldabra. It has invariably been regarded as a full species, and this seems justified. The dingy grey upperside and mainly white underside of two immature specimens in the British Museum is most distinctive, and for full details see Vaurie (1949, 231). By contrast, immature

specimens of adsimilis and forficatus are black above, and black below with mere fringes of white (no immature specimen of fuscipennis or waldeni has been available). Aldabranus is also remarkable in that the frontal feathers, instead of being short and inconspicuous as in adsimilis, are relatively long, curving forward and slightly upward, thus showing a tendency towards forficatus. In size, as shown by wing-length, aldabranus is smaller than any other form inhabiting the Malagasy Region except D. f. forficatus of Madagascar, see the measurements in Vaurie (1949). Possibly it has been derived from Madagascar via Gloriosa and the remainder of the Aldabra archipelago, where however the family is unrepresented. If so, either the frontal feathers have since become reduced in length; or, when colonisation occurred, the development of the frontal feathers in forficatus was less than it is now.

Nectarinia sovimanga aldabrensis (Ridgway)   Souimanga Sunbird

Williams (1953a) has revised the subspecies of this sunbird, and the following findings differ in no more than minor detail. N. s. sovimanga (Gmelin) occupies the whole of Madagascar except for the southwest, where it is replaced by N. s. apolis (Hartert), in which the yellow tones are more whitish and the olive more greyish, no doubt a reflection of the relatively arid climate in which it lives. The nominate form also occurs on Gloriosa, and the species has colonised the Aldabra archipelago. Unfortunately the only two specimens collected on Astove cannot be traced (Williams 1953a, 503) though it was still plentiful there in 1964 (Bourne 1966), and it is most desirable that further specimens should be collected. The adult males of the subspecies inhabiting Cosmoledo (N. s. buchenorum (Williams)), Assumption (N. s. abbotti (Ridgway)) and Aldabra (N. s. aldabrensis (Ridgway)) all have more extensive black below the reddish maroon chest-band than in N. s. sovimanga, in which the black does not extend for more than about 10 mm., barely reaching the upper abdomen. In buchenorum the whole of the underside below the chest-band is black, and this is almost so in abbotti, though there is just a trace of dull olive on the lower abdomen. Even aldabrensis has more extensive black than in nominate sovimanga, though the whole of the lower abdomen is dull olive. Buchenorum can also be distinguished from the other subspecies by the more brownish, less reddish tone of the chest-band. Williams indicates that the chest-band is broader in aldabrensis and abbotti than the other subspecies, though I cannot perceive this. Nominate sovimanga and aldabrensis have the lower back olive, the rump and upper tail-coverts black without any metallic green. Abbotti differs from these two in having metallic green tips to the feathers of the rump and upper tail-coverts. Buchenorum is like abbotti in this respect, but in addition has the lower back black instead of olive. Thus the tendency to blackening has its extreme in buchenorum.

Considering now females as well as males, the olive tones in aldabrensis are duller than in nominate sovimanga, the upperside brownish in tone, the abdomen less yellowish. This also applies to abbotti, the only available female of which seems indistinguishable from females of aldabrensis. In buchenorum this tendency to dullness is still more pronounced, two females (one of them a juvenile, with skull-ossification not started) being grey above, with barely a tinge of olive, and yellow wash on the abdomen hardly apparent. It is curious

that this blackening in the male, and reduction of olive and yellow in both sexes, should find their extremes on Cosmoledo rather than on Aldabra, geographically the more remote.

Possible N. dussumieri Hartlaub of the Seychelles is also derived from sovimana stock. Dussumieri is still duller than buchenorum. In the male, metallic is confined to blue on the chin and throat, and a trace on the shoulder, with a slight bluish sheen on the crown. Three specimens showed traces of retention of the maroon chest-band. Yellow (or orange) pectoral tufts are fully retained, and incidentally I agree with Williams (1953b) that they vary in colour individually, in some specimens being a mixture of the two colours, so that there is no case for the recognition of N. mahei (Nicoll). Otherwise both sexes are brown in colour, lacking any olive or yellow tones, though two juveniles in Cambridge have a dull olive wash on the abdomen, and Williams (1953b) mentions traces of olive, and yellowish grey undertail-coverts, in a juvenile available to him.

The following are measurements in mm. of the material examined (sample only of nominate sovimanga measured), in London and Cambridge, including in the case of dussumieri also that in Paris:

	Wing	Tail	Culmen from base
N. s. sovimanga (Madagascar, Gloriosa)			
14 ♂♂	51 - 56 (54.1)	33 - 40 (36.6)	20.5 - 24 (22.1)
16 ♀♀	47 - 52 (49.4)	28 - 33 (31.1)	19 - 21.5 (20.4)
N. s. buchenorum (Cosmoledo)			
1 ♂	54	39	20
1 ♀	51	33	17
1 juv. ♀	50	31	16
N. s. abbotti (Assumption)			
5 ♂♂	53 55 (53.8)	37 - 41 (39.2)	20 - 21 (20.2)
1 ♀	49	34	16+
N. s. aldabrensis (Aldabra)			
7 ♂♂	52 - 54 (52.4)	35 - 39 (37.3)	19 - 20 (19.7)
6 ♀♀	47 - 50 (48.4)	30 - 35 (32.2)	18 - 19 (18.3)
N. dussumieri (Seychelles)			
35 ♂♂	59 - 65 (62.1)	37 - 44 (40.3)	22 - 25 (23.7)
6 ♀♀	56 - 58 (57.1)	35 - 37 (35.7)	22.5 - 24 (23.1)

It will be seen that, apart from the colour-differences, the Aldabra archipelago forms all have a shorter bill than nominate sovimanga. Dussumieri is altogether larger. If it is derived from sovimanga stock, as it probably is, this could be a reflection of the same slight tendency to gigantism as in Caprimulgus madagascariensis aldabrensis.

Gaymer gives the weight of a male of N. s. aldabrensis which he collected as 7.5 gms., and of a female as 6.0 gms. The following measurements in mm. have been supplied by him for other specimens mist-netted and subsequently released:

	Wing	Tail	Culmen (exposed part)
2 ♂♂	54 55	31 38	16 16.5
3 ♀♀	47 49 49	25 28 31	13 16 16

One of these two males weighed 7.5 gms., the three females 5.5, 6.0, 7.5 gms. Gaymer records the bill as black in males, very dark brown in females, the feet as black and the iris as very dark brown in both sexes.

Males of aldabrensis collected in March, July, October and November are all in full metallic dress, as are males of abbotti collected in March and one of buchenorum (the type) on 15 April. Rand (1936, 470) gives evidence of nominate sovimanga breeding in September-December. There may not be a dull off-season dress in any subspecies. In the British Museum there are two males of nominate sovimanga in full dress collected in May, two in June, nine in July and three in August.

Finally, a word is necessary in regard to N. comorensis (Peters), of Anjouan, in the Comoros, which Williams (1953a, 503) suggests may prove to be conspecific with sovimanga when specimens are available from Astove. Undoubtedly comorensis is derived from sovimanga. Superficially it closely resembles N. s. buchenorum. But in particular the male has red instead of yellow pectoral tufts, and it also has the abdomen black slightly glossed bluish instead of matt brownish black, while the female is brighter olive above than in any of the Aldabra archipelago subspecies. It is unlikely that colonisation of this archipelago was via the Comoros. On Grand Comoro and Moheli, and on Mayotte, there are other very distinct small species, respectively N. humbloti (Milne-Edwards and Oustalet) and N. coquereli Verreaux, the origin of which is discussed in Benson (1960b, 196, 202-203). When specimens are available from Astove, it is almost certain that they will prove to represent sovimanga rather than comorensis.

Zosterops maderaspatana aldabrensis Ridgway   Madagascar White-eye

The taxonomy of the Zosteropidae of the Ethiopian and Malagasy Regions as a whole has been very fully discussed by Moreau (1957), from whom the details which follow have been derived, as augmented for the Comoros by Benson (1960a, 88-91) and confirmed by recent personal examination. In Madagascar the only representative of the family is Z. maderaspatana (Linnaeus). This grey-bellied species has colonised Anjouan and Moheli in the Comoros, each of which has its own recognisable subspecies, while Mayotte is inhabited

by the very distinctively coloured Z. mayottensis Schlegel, and Grand Comoro by two forms considered of African origin. Z. m. maderaspatana of Madagascar exists undifferentiated on Gloriosa, and perhaps also on Cosmoledo and Astove (Moreau 1957, 402), but material is insufficient to decide the point for certain. Curiously, the family is apparently unrepresented on Assumption. Z. m. aldabrensis differs only from nominate maderaspatana in being yellower above, and relatively longer tailed and shorter winged. Measurements in mm. of two males which were not available to Moreau (1957, 428), the first in Cambridge, the second collected by Gaymer, are as follows:

Wing	Tail	Culmen from base
52	40	11.5
54	39	12.5

Gaymer has provided the following further particulars for his specimen: bill, upper mandible charcoal grey, lower pale blue-grey; legs pale blue-grey, likewise feet, with lemon soles; iris light brown, pupil with dark blue sheen; weight 6.5 gms.

In conclusion, aldabrensis was presumably derived from Madagascar, via Cosmoledo and Astove rather than via the Comoros.

Foudia eminentissima aldabrana Ridgway   Red-headed Forest Fody

The details which follow in this paragraph are derived from Moreau (1960), the characters of aldabrana being confirmed from personal examination of material. In Madagascar and the Comoros this ploceine genus, confined to the Malagasy Region, is represented by two species, F. eminentissima Bonaparte inhabiting evergreen forest and F. madagascariensis (Linnaeus) in drier, more open country. On Mauritius there is an analogous segregation between F. rubra (Gmelin) and madagascariensis. The former is the local representative of eminentissima, from which it differs mainly by its more slender, insectivorous type of beak. Other, more distinct, species inhabit Rodriguez (F. flavicans Newton) and the Seychelles (F. sechellarum Newton). Madagascariensis is also known from the Amirantes and the Seychelles, but outside Madagascar may be a recent introduction by human agency, and shows no subspecific variation. Eminentissima is otherwise only known from Aldabra, and the genus is unknown on Assumption, Cosmoledo, Astove or Gloriosa. F. e. aldabrana is a well marked subspecies, presumably derived from the Comoros, each island of which has its own subspecies. In F. e. algondae (Schlegel) of Mayotte, the driest of the Comoros, the male has the red of the head less crimson, more orange in tone than on the other three islands. This is accentuated still further in aldabrana, and may be connected with a still drier, less shady environment. Also, melanin in the contour feathers is less intense, so that the ground-colour of the streaky back is paler, and the olive-grey of the underside is replaced by pale dull yellow. Two males which have been available to me have the olive of the mantle largely replaced by red, and Benson (1960a, 100) notes that most Comoro males have a few crimson feathers to be found in part of the plumage. The bill of aldabrana is stouter than in any other subspecies, possibly in adaptation to a seed rather than an insect diet.

According to Moreau (1960, 38), and see also Benson (1960a, 101), it is uncertain whether in the humid Comoro environment there is a dull nonbreeding plumage. However, Moreau (1960, 34) quotes Rand that there is in F. e. omissa Rothschild. As to Aldabra, a male in Cambridge collected by Abbott in October is in breeding dress, the red fully developed. This is also confirmed by Ridgway (1895, 538), who quotes Abbott that nesting takes place in November, December and January (and see also Bendire 1894). Two males collected by Gaymer on 14 and 30 November are in breeding dress, as are four collected by Nicoll in mid-March. Nicoll (1908, 116) also indicates that there were many such birds at the time of his visit, while Morris (1963), who visited Aldabra in January and February, from his account obviously also saw males in breeding dress. However, two males lent to me, collected by Cherbonnier on 12 and 20 May, are strikingly different. The first has no sign of red, the second has a small amount on the head and chest. No less remarkable is it that in both the olive tones of the mantle are replaced by rufous brown, this also being the coloration of the crown (obscurely streaked with dusky) and the rump. The chin, throat and abdomen are dull yellow, of the same tone as on the abdomen of males in breeding dress, and there is a heavy brownish wash across the chest and on the flanks. Also, the bill, instead of being black, is dark brown in the first specimen, paler horn in the second. Two females collected by Cherbonnier in May, which I have also been lent, are similar to the first male, in their rufous brown tones above and brownish wash on the chest and flanks. But a female collected by Nicoll on 14 March has olive tones above, and the whole underside dull yellow, with some olive (not brownish) wash rather strictly confined to the flanks. All three of these females have the bill horn coloured. There are two further specimens collected by Gaymer on 14 November, similar in all respects to Nicoll's female. One is sexed as a male, the other as a female. But see the measurements below, they have wings 78, 80, tails both 53 mm. Thus they seem to be both males, and to have failed to develop into breeding dress. They are placed accordingly in the measurements.[1]

It seems clear that, whatever may be the situation in the humid Comoros, on Aldabra there are well-marked seasonal plumage changes in both sexes, the colour of the bill of the male also changing.

Moreau (1960, 35) gives measurements for only four males of aldabrana, and it is worth giving them for all of the material now examined (in mm.):

	Wing	Tail	Culmen from base
11 ♂ ♂	78 - 84 (80.3)	48 - 57 (52.5)	17 - 20.5 (18.6)
3 ♀ ♀	72 74 74	43 47 47	18 18.5 20

The tail/wing ratio for males works out at 65, the same figure as arrived at by Moreau. It is curious that, although males have longer tails and wings than females, the bill measurements are so similar. The Comoro figures in Benson (1960a, 100) show a sexual disparity in all three series of measurements. How-

[1] Gaymer states, however, that the specimen with wing 80 mm. was a female with large gonads - Editor.

ever, only three females of aldabrana were available. Nevertheless, neither is there any indication from the further figures given below of any difference in the bill.

Gaymer gives the weights of the four specimens which he collected as 21, 24, 25, 26 gms. The following summary has been compiled from figures in mm. supplied by him for specimens mist-netted and subsequently released, all caught in November:

	Wing	Tail	Culmen (exposed part)	Notes
10 ♂♂	78 - 85 (80.9)	49 - 58 (53.7)	16 - 19 (17.6)	(a)
juv. ♂♂	62 76 76 83	46 46 48 52	17 18 18 19	(b)
13 ♀♀	68 - 75 (72.1)	43 - 53 (47.8)	16 - 19 (17.4)	
9 ○○	76 - 79 (77.3)	45 - 52 (50.0)	16 - 19 (17.3)	(c)

Notes: (a) in breeding dress.
(b) in female-like dress, but showing traces of red in plumage, so presumably males.
(c) wholly in female-like dress, but those in second series perhaps too long-winged to be females.

Weights in gms. of these four series were respectively as follows: 22.5 - 27 (25.7): 24, 25.5, 27.5, 27.5; 21 - 27.5 (24.8); 23 - 27.5 (24.9).

(b) Migrants

(i) Already recorded

Porzana marginalis Hartlaub   Strip Crake

There is a male in the American Museum of Natural History, collected by F. R. Mortimer on West Island (Ile Picard), Aldabra, 10 December 1904 (Benson 1964, 56). This occurrence may be considered as accidental, and is the only record known to me from the Malagasy Region. Benson (1964, 56) has presented data suggesting that this species is migratory in southern Africa, only normally present during the rains, when it breeds. This particular specimen was probably blown off course on southward migration.

Squatarola squatarola (Linnaeus)   Grey Plover

Collected by Nicoll (1906, 703, under the name S. helvetica) on Aldabra, and reported as common. At least one seen by Morris (1963). Probably regular from late September to early April, as in Madagascar (Rand 1936, 351), and see also Benson (1960a, 43) for the Comoros.

Charadrius leschenaultii Lesson   Great Sand Plover

Collected by Abbott on Aldabra, and noted as "rather common" (Ridgway 1895, 527, under the name Aegialitis geoffroyi). There is also a specimen in the British Museum collected in 1906. Seen by Morris (1963). Dupont (1907) lists it from throughout the archipelago. Rand (1936, 354) found it fairly common in Madagascar from September to early May, and Benson (1960a, 43) found it on all four islands in the Comoros.

Numenius phaeopus phaeopus (Linnaeus) Whimbrel

Collected by Abbott on Aldabra, recorded as common (Ridgway 1895, 528). Also collected there by Voeltzkow (Berlepsch 1899, 494). Dupont (1907) lists both N. phaeopus and N. madagascariensis (presumably meaning N. arquata) from throughout the archipelago. Fryer (1911, 420), who was in the archipelago from August to February, states that both N. phaeopus and arquata were abundant. However, in Madagascar and the Comoros the former outnumbers the latter (Rand 1936, 348; Benson 1960a, 44). Bourne (1966) records hundreds of "curlews" Numenius sp. A solitary "curlew" seen by Morris (1963) may also have been N. phaeopus.

Numenius arquata orientalis Brehm Curlew

Under the heading N. madagascariensis, though presumably N. arquata was intended, found by Abbott to be not common, though no specimen was collected (Ridgway 1895, 527). See also other possible records under N. phaeopus. N. a. orientalis has been collected in the Comoros (Benson 1960a, 44), and the occurrence of N. a. arquata (Linnaeus) seems unlikely, see especially Rudebeck (1963, 499-501).

Tringa nebularia (Gunnerus) Greenshank

A specimen collected by Abbott on Aldabra (Ridgway 1895, 527) appears to be the only record from anywhere in the archipelago, other than the listing of it from throughout by Dupont (1907, under the name T. glottis). It may not be so very uncommon, for Benson (1960a, 44) gives a number of records from the Comoros, including one of a flock of 40, and Rand (1936, 349) found it in Madagascar from late November to early March.

Tringa glareola Linnaeus Wood Sandpiper

One specimen collected by Abbott on Aldabra, and he noted it as "rather scarce" (Ridgway 1895, 527). This appears to be the only record from the Malagasy Region, so that it must have been an accidental occurrence. This species perfers inland marshes to sea-coasts.

Actitis hypoleucos (Linnaeus) Common Sandpiper

One specimen collected by Abbott on Aldabra, but he found it "not common" (Ridgway 1895, 527). Dupont (1907) lists it from throughout the archipelago. It may not be rare, for Benson (1960a, 44) found it fairly common in the Comoros, Rand (1936, 349) records it from August to March in Madagascar, and it is even abundant and regular on Réunion and Mauritius (Berlioz 1946, 35).

Arenaria interpres interpres (Linnaeus) Turnstone

Collected by Abbott on Aldabra, where very common (Ridgway 1895, 527). Also collected there by Cherbonnier in May. Recorded by Fryer (1911, 420) as abundant in the archipelago throughout his stay, from August to February. In

March 1964 thousands were seen on Aldabra, also large numbers on Cosmoledo and 100 on Assumption (Bourne 1966). Dupont (1907) lists it from throughout the archipelago. Rand (1936, 351) found it fairly common in Madagascar, from late September to early May, while Benson (1960a, 43) gives various records from the Comoros.

Crocethia alba (Pallas)   Sanderling

Collected by Abbott on Aldabra, said to be common (Ridgway 1895, 527, under the name Calidris arenaria). Nicoll (1906, 704), in dealing with the next species, mentions seeing it there, and (1908, 118) saw "a few". Although Benson (1960a, 44) gives only two records from the Comoros, Rand (1936, 350) found it fairly common in Madagascar from late September to early March.

Erolia testacea (Pallas)   Curlew Sandpiper

Abbott records a small flock, and collected two specimens (Ridgway 1895, 527, under the name Tringa ferruginea). Nicoll (1906, 704, under T. subarquata) saw several, and collected a specimen. Five "dunlins" seen by Morris (1963) were probably this species. Benson (1960a, 43, under Calidris ferruginea) gives a few records from the Comoros, and Rand (1936, 349) found it fairly common from October to early March in Madagascar.

Eurystomus glaucurus glaucurus (Müller)   Broad-billed Roller

At least four specimens have been collected on Aldabra: one in November 1906 (Benson 1960a, 55); one by Abbott on 10 December 1892, and one by Mortimer on 24 December 1904 (Benson 1963a); a female by Gaymer on 9 December 1964, wing 197 mm. Abbott (in Ridgway 1895, 534) was informed of several others previously seen there. Vesey-FitzGerald (1940, 488) saw one on Cosmoledo, 6 October. There are at least four specimens from the Comoros, one of which is dated 7 November, one 10 April, the others being undated (Benson 1960a, 55; 1963a).

According to Moreau (1966, 249-250), this subspecies (there are two other, smaller, ones which breed in Africa, see White 1965, 237) is present in Madagascar from October to March, breeding in October and November. The main "winter" quarters are probably in the Congo. Records from Malawi and Zambia are all for October-November and February-April, suggesting that the birds are only on passage through these territories. This must also apply to the Aldabra, Cosmoledo and Comoro records. Such a passage may be regular in small numbers.

Apus apus apus (Linnaeus)   Eurasian Swift

Abbott collected a specimen on 1 December (Ridgway 1895, 534) which I have been lent. It agrees with material in the British Museum of nominate apus rather than of A. a. pekinensis (Swinhoe). The label is endorsed "The only one observed - undoubtedly accidental straggler". This appears to be the only record of the species from the Malagasy Region, though it is plentiful as a visitor to southern Africa, whence there is no lack of material of both subspecies (Irwin and Benson 1966, 15).

Riparia riparia riparia (Linnaeus)   Sand-Martin

One was collected by Abbott on Aldabra on 2 December, another by him on Gloriosa on 29 January (Benson 1963a). Although this is a common palaearctic migrant to southern Africa, it is probably merely casual in the Malagasy Region, the only other record traced being a specimen from Lac Iotry, Madagascar (Rand 1936, 427).

Phedina borbonica madagascariensis Hartlaub   Mascarene Martin

Abbott collected a specimen on Aldabra on 19 November, listed by Ridgway (1895, 535) as P. borbonica, and further reported on by Benson (1963a). No doubt it was on passage, even though the breeding season in Madagascar includes October and November (Moreau 1966, 252). As Moreau points out, the movements of this bird are not understood. Small numbers have been reported from Pemba Island in September-March, prior to 1930. The only other African record is from Lake Chilwa, Malawi, where hundreds were seen between 28 June and 30 July 1944.

Motacilla flava lutea (Gmelin)   Yellow Wagtail

Abbott collected a male on Aldabra on 20 December (Ridgway 1895, 535, under M. campestris). It is evidently by a slip of the pen that Watson, Zusi and Storer (1963, 198) place this record under the Tawny Pipit Anthus campestris. I have been lent this specimen, the label of which is endorsed "accidental visitor". Indeed this seems to be the only record of the species from the Malagasy Region. The specimen is in full adult dress, except for some brownish feathers on the underside. It has the crown mainly green, with yellow restricted to the fore part and the forehead, and a well-developed yellow eyestripe. Thus in colour it agrees with the description by Vaurie (1959, 75, 78) of M. f. flavissima Blyth rather than lutea. However, the view of Dowsett (1965) that such specimens from eastern Africa are individuals of lutea showing the characters of flavissima is accepted, and applies also to Abbott's specimen.

Muscicapa sp.   Flycatcher

Under this heading Abbott (in Ridgway 1895, 535) mentions seeing a small grey flycatcher with white rump on Aldabra in December. It is impossible to make any suggestion as to the identity of this bird, which might not have been a muscicapid at all.

(ii) Not yet recorded, but likely to occur

Ardeola idae (Hartlaub)   Madagascar Squacco Heron

According to Moreau (1966, 249), this species is said to breed in Madagascar in the rains, and occurs in tropical eastern Africa as an off-season visitor during May to October. Benson (1960a, 34) collected it on Mayotte, in the Comoros, in October, presumably on passage back to Madagascar. It is likely to occur also on Aldabra on passage.

Falco eleonorae Gené   Eleonora's Falcon
Falco concolor Temminck   Sooty Falcon

According to Moreau (1966, 68) these two species winter entirely in Madagascar. Nicoll (1906, 680) records a specimen of F. subbuteo from Mayotte, in the Comoros, but it may well be an eleonorae (Benson 1960a, 105). There is an undated specimen of F. concolor from Tanga, in coastal north-eastern Tanzania, in Paris, and Reichenow (1900, 630) gives two other records of this species from eastern Tanzania, and one from Mozambique. Both these palaearctic breeders may well pass over Aldabra.

Charadrius hiaticula tundrae (Lowe)   Ringed Plover

Rand (1936, 352) records it from Madagascar during December to March, and Benson saw it regularly from late August until he left the Comoros in late November. It may well be regular on Aldabra.

Limosa lapponica lapponica (Linnaeus)   Bar-tailed Godwit

Since Rand (1936, 349) refers to its occurrence in the Seychelles and Madagascar, it presumably occurs occasionally on Aldabra.

Tringa totanus (Linnaeus)   Redshank

A record by Dupont (1907, under the name T. glottis) for the Greenshank T. nebularia has already been referred to under that species. Dupont also lists T. nebularia, which he calls "Redshank", from Aldabra. It would seem that there has been a clerical error, and that both records refer to the Greenshank T. nebularia. Watson, Zusi and Storer (1963, 30) do not give any occurrence of T. totanus nearer than the Maldives. It is true that Dawson (1963a, 7) mentions it from the Seychelles. But its occurrence anywhere in the western Indian Ocean south of the equator requires proper substantiation, and moreover Rudeback (1963, 492) finds that south of 10°N. in Africa it is scarce and irregular.

The necessity for the inclusion of this species has arisen from Dupont's apparent clerical error. It can only be extremely rare on Aldabra.

Xenus cinereus (Güldenstaedt)   Terek Sandpiper

Rand (1936, 348) found it not uncommon in Madagascar, and there is even a specimen in Cambridge from Mauritius, collected on 13 January 1864. Benson (1960a, 44) gives one record from the Comoros. Its occasional occurrence on Aldabra is very probable.

Erolia minuta (Leisler)   Little Stint

Newton (1867, 343) found it common on Mahé, in the Seychelles, and there is a specimen collected there by him in Cambridge. Benson (1960a, 44) collected one on Grand Comoro, and Rand (1936, 350) gives one record from

Madagascar. It must occur occasionally on Aldabra, but its listing by Dupont (1907, under Tringa minuta) from throughout the archipelago requires confirmation.

Glareola ocularis Verreaux   Madagascar Pratincole
Glareola maldivarum Forster   Eastern Collared Pratincole

Moreau (1966, 251) refers to Galachrysia nuchalis, no doubt really meaning Glareola acularis, as quite common in coastal Kenya in August and September. Benson (1960a, 45) collected a specimen on Mayotte, in the Comoros, on 28 October. A. D. Forbes-Watson tells me he saw one on the Dzaoudzi airstrip, Mayotte, on 24 October 1965, and five days earlier three on the Moroni airstrip, Grand Comoro. Presumably all these Comoro records refer to birds on delayed passage back to Madagascar. It is likely to also occur on passage on Aldabra.

G. maldivarum, treated by Watson, Zusi and Storer (1963) as conspecific with pratincola, is known as an occasional visitor from the palaearctic to the Seychelles (Benson and Roux, in press) and has also been recorded from Mauritius (Rountree and others 1952, 179). It could also occur on Aldabra.

Cuculus canorus Linnaeus   Grey Cuckoo

Nicoll (1906, 700) saw a cuckoo on Aldabra which he thought was this species. Its occasional occurrence as a migrant from the palaearctic is possible. Benson and Roux (in press) record such a specimen from Mahé, in the Seychelles. Abbott (in Ridgway 1895, 514) also gives a very probable record from Mahé, though he did not retain a specimen.

Cuculus poliocephalus rochii Hartlaub   Lesser Cuckoo

According to Moreau (1966, 249), the Madagascar breeding subspecies is present in most of the island only from the end of September to April, and has been recorded from Kenya, Uganda, Tanzania, and the south-eastern Congo as a non-breeding visitor from June to September. So far there is no record from any of the intervening islands between Madagascar and eastern tropical Africa. But its occurrence on passage, including Aldabra, is likely.

Collocalia francica (Gmelin)   Cave Swiftlet

Abbott saw a Collocalia sp. on Aldabra several times (Ridgway 1895, 535). Possibly the form frequenting Mahé, in the Seychelles, C. f. elaphra Oberholser, occurs occasionally on Aldabra. The genus is only otherwise represented in the Malagasy Region on Mauritius and Réunion, and its status in Madagascar is problematical (Moreau 1966, 331).

Merops superciliosus superciliosus Linnaeus   Blue-cheeked Bee-eater

As Moreau (1966, 251) indicates, this subspecies, which breeds in Madagascar (and in tropical eastern Africa), has for long been regarded as a migrant between Madagascar and Africa. But he concludes that large-scale migration

from Madagascar remains to be proved. However, it probably occurs occasionally as a wanderer on Aldabra, especially as it breeds on Mayotte, in the Comoros (Benson, 1960a, 59).

Hirundo rustica Linnaeus Swallow

J. H. Crook has a record of it as a straggler to Frégate, in the Seychelles, in November (Lousteau-Lalanne 1962, 30). Rand (1936, 427) saw six or seven at Tulear, Madagascar, in January. This species is very plentiful as a visitor from the palaearctic to southern Africa, and may be expected to occur occasionally on Aldabra.

(c) Of Uncertain Status

Bubulcus ibis (Linnaeus) Cattle Egret

The only definite record traced from Aldabra is of one seen by Abbott (Ridgway 1895, 531), though Gaymer states that they are a recent arrival, and that in 1964 about 100 birds were roosting at Takamaka, in the eastern part of Aldabra. Bourne (1966) gives a record of six seen on Astove. With any development of the atoll, a breeding colony could well become established.

It is impossible to suggest whence the birds seen on Aldabra and Astove might have emanated. The nominate subspecies breeds in Madagascar (Rand 1936, 332) and on Anjouan, in the Comoros (Benson 1960a, 33), while the populations of the Amirantes and the Seychelles may have to be known as B. i. seychellarum (Salomonsen), despite the strictures on its validity by Dawson (1966b). As pointed out by Benson (1960a, 33), two of the specimens on which Salomonsen based his description are from the remote Bird Island, in the Seychelles. The third, in Paris, which I examined in 1966, is from Ile Cousine, and its wing measures 236 mm. only. Unfortunately the buff coloration is confined merely to a trace on the forehead, and I found it impossible to decide whether it was more golden cinnamon, as claimed for seychellarum, or buff, as in the nominate form.

Ridley and Percy (1958, 31, 45) found this species to be a serious predator of eggs on Desnoeufs Island, in the Amirantes, and to a lesser extent on Bird Island. They suggest that it was introduced at some time, but were unable to trace when or from where. If it was introduced, it seems odd that Abbott (in Ridgway 1895, 531) found it already plentiful in such remote places as Coetivy and the Amirantes 75 years ago. It may have established itself unaided and have evolved into a recognisable subspecies. If so, the coloration of seychellarum suggests a derivation from the Asiatic B. i. coromandus Boddaert. If the Asiatic Ixobrychus sinensis could establish itself unaided in the Seychelles as would appear to be the case (Benson, in preparation), there seems no reason why Bubulcus ibis should not also achieve this (and in the Amirantes). Further material is required of the latter species in order further to assess the validity of seychellarum.

Egretta alba melanorhynchos (Wagler)   Great White Heron

Bourne (1966) refers to egrets which were abundant on Cosmoledo, and were evidently E. garzetta. Also present were five larger white birds which could have been E. alba, though the description of the bottom of the feet as orange is puzzling. One would expect the colour to be black, like the remainder of the feet and the legs. But be that as it may, it is likely that this species occurs occasionally as a wanderer, and might even establish itself, in the Aldabra archipelago, as it breeds on Moheli, in the Comoros (Benson 1960a, 32).

Phoenicopterus ruber roseus Pallas   Greater Flamingo
Phoenicopterus minor Geoffroy   Lesser Flamino

Abbott (in Ridgway 1895, 529) collected five specimens of a flamingo on Aldabra, which he thought was a breeding resident, there probably being between 500 and 1,000 birds on the atoll. But Nicoll (1906, 703) in his admittedly short stay did not see any, and was also informed that there was no breeding population. Dupont (1907, 23) records flamingos from Aldabra "all along the South East and South on the shores of the lagoon in numerous flocks of several hundreds". In his list he cites P. erythraeus, presumed to be the same as P. ruber roseus. Possibly the specimen dated October 1906 in the British Museum, mentioned below, was collected by him, since Dupont was on Aldabra in that month. Fryer (1911, 419) refers to the presence of a resident population of P. minor on Aldabra. According to Gaymer (1966), about fifty flamingos live in the southeast of the atoll, and probably breed there. He suggests that they belong to a new subspecies of P. ruber. Watson, Zusi and Storer (1963, 194) consider that five specimens (undoubtedly those collected by Abbott) appear aberrant, and refer them to P. ruber subsp.

Watson has most kindly lent me one of these five specimens, a male, consisting of a head and whole skin of the body as well. There is another such (unsexed) specimen in the British Museum, collected on Aldabra in October 1906, part of a Howard Saunders Bequest. Their measurements in mm. now follow, together with those of the other four specimens collected by Abbott, which Watson has been so kind as to supply (those of the first male listed were taken by myself from the specimen which I was lent):

	♂	♂	♀	♀	♀	○
Wing	386	356	371	371	355	384
Tail	140	135	134	133	130	138
Tarsus	245	253	265	255	235	275
Culmen (exposed part)	120	115	118	110.5	116	122

These figures agree substantially with those of P. r. roseus provided by Witherby and others (1941, 166). The two Aldabra specimens personally examined, compared to material of this form from Africa in the British Museum, show no difference in either structure or colour. Both appear to be adult. The body-plumage of neither has any of the pink tinge said by Witherby and others to characterise adults, but several other adults also lacked any such tinge. It may

be that the colour varies quite temporarily, according to the food available. Abbott gives the iris of the specimen which I was lent as straw-yellow, and this also agrees quite well with Witherby and others (1941), who give it as lemon-yellow.

Rand (1936, 342) refers a specimen from Lac Iotry, south-western Madagascar, to P. r. antiquorum (=P. r. roseus) without any question, and he states that P. minor is very common there. Griveaud (1960) records only P. ruber from Lac Iotry, estimating the numbers of flamingos there to be between 25,000 and 30,000. The lower photograph on page 38 of his paper is certainly of a P. ruber, not a P. minor.

Satisfactory as it would be in the cause of the conservation of Aldabra to be able to show that an endemic form of Phoenicopterus exists there, I cannot find any such evidence. Dr Watson has also recently written to me to the effect that, despite the comment of Watson and others (1963), he no longer considers Abbott's material separable from P. r. roseus. Nor can I even find any definitive evidence of breeding on Aldabra. It may well be that both P. ruber and minor do so occasionally, particularly as minor as well as ruber is said to occur in Madagascar. So far the only report of the occurrence of P. minor on Aldabra is from Fryer, but it is very possible that he confused it with ruber. It should be emphasised that both species seem highly nomadic and capricious in their places of breeding. Thus Brown (1957) records attempted breeding by P. minor (a few ruber were also present) in north-eastern Northern Rhodesia (now Zambia) in 1955. There is no other such evidence from Zambia, and the attempt was due to unusually dry conditions preceding (see also Benson 1963b, 627).

Milvus migrans parasiticus (Daudin) Black Kite

Abbott collected two specimens on Aldabra, on 2 October and 19 December, stating that kites are occasionally observed but are not common, while he apparently saw it also on Gloriosa, which he visited in September (Ridgway 1895, 525, 533). Nicoll (1906, 687; 1908, 102) saw this species on Gloriosa in March, and regarded it as non-resident. Its status on Aldabra (and Gloriosa) cannot be regarded as certain, but presumably it is non-resident. Elsewhere in the Malagasy Region it is only known from Madagascar (Rand 1936, 381) and the Comoros (Benson 1960a, 36), where it is common. Rand saw an occupied nest in Madagascar in October. In southern Africa it is only normally present, as a breeding visitor, from August to March; see for example White (1965, 58). Although there is no definite evidence, it is reasonable to suppose that this also applies to Madagascar and the Comoros. If this is so, it could pass through Aldabra on its way to and from non-breeding quarters, perhaps in equatorial Africa. However, the dates of Abbott's specimens are not in keeping with this. The possibility cannot be excluded that the odd pair breeds on Aldabra, and perhaps also on Gloriosa.

Dromas ardeola Paykull Crab Plover

Abbott saw "large flocks" on Aldabra, and collected two specimens (Ridgway 1895, 527). It was also collected by Voeltzkow (Berlepsch 1899, 494). Nicoll (1906, 703) saw "enormous flocks" on Aldabra in mid-March. From observations also made in March, Bourne (1966) records "thousands" on Aldabra, and

20 and 40 respectively on Cosmoledo and Assumption. Morris (1963), who made short visits in January and February to Aldabra, records merely "several" and "three". But he might have been unlucky, and not have visited a locality on the atoll where large numbers were congregated. Dupont (1907) lists it from throughout the archipelago.

The status of this species on Aldabra is uncertain. But in view of the large numbers which have been reported it may well breed there. The nearest breeding locality to Aldabra which Benson (1960a, 45) was able to trace was the coast of former British Somaliland, though according to Watson, Zusi and Storer (1963, 115, 121) it may also do so in the Maldives and the Chagos Archipelago.

Corvus albus Müller   Pied Crow

This crow has presumably colonised the Malagasy Region from Africa, but from the evolutionary aspect is of no interest, and no subspecies from throughout its wide range has ever been proposed. It definitely breeds in Madagascar and the Comoros, and apparently also does so on Aldabra, Assumption and Gloriosa, though this requires confirmation for Aldabra. It has also been recorded from Cosmoledo and Astove.

Benson (1960a, 87) found it common throughout the Comoros. He saw nestlings in early November, and probably throughout its range in southern Africa and the Malagasy Region it is essentially a pre-rains breeder. Abbott, who was on Aldabra from September to December, found it not common, likewise on Assumption, which he visited in September, yet plentiful on Gloriosa, visited in January and February (Ridgway 1895, 537, under C. scapulatus). While Abbott gives no evidence of breeding on any of these islands, Nicoll (1906, 689) was informed that it was resident on Gloriosa, saw empty nests on Assumption in March (1906, 693), while like Abbott he (1906, 700) found it uncommon on Aldabra, but was only there from 13 to 16 March. It does not appear in the catalogue of specimens collected by Voeltzkow (Berlepsch 1899). Vesey-FitzGerald (1940, 488) states that it is a visitor to Cosmoledo, Astove and Assumption, and nests on Aldabra, but gives no further details. Boulton (1960), who visited Aldabra in November 1959, records it, but gives no further information. Morris (1963), who visited the island twice in January and February, apparently did not see it. Gaymer collected a specimen on 5 December. Dupont (1907) lists it from throughout the archipelago.

In the light of the foregoing, it is remarkable that, as a result of the visit of H.M.S. Owen in March 1964, while Bourne (1966) was unable to give any record from Assumption or Astove, and only one pair from Cosmoledo ("the first for many years"), yet there were "hundreds" on Aldabra. Clearly the status of this crow on Aldabra and neighbouring islands is in need of further investigation. Has it recently increased there, or is there perhaps some movement between the islands? It is my experience in Africa that any extension of human settlement, with an increase in the availability of offal, favours it. The availability or otherwise of suitable tall trees as nesting sites may also be important (see for example Benson 1953, 69). The statement by Vesey-FitzGerald that it breeds on Aldabra should be confirmed, and in the meantime it is best to include the Pied Crow among the species of uncertain status.

(2) Sea Birds

No doubt species additional to those now listed occur occasionally on or around Aldabra, more especially representatives of the families Procellariidae and Hydrobatidae. Such possibilities can be found in Watson, Zusi and Storer (1963, 15-19). In the British Museum there is a specimen of Wilson's Petrel Oceanites oceanicus labelled as from Aldabra, November 1906. However, as it is further stated on the label that it was collected at sea, as far north as "latitude 2°", it evidently was not obtained so very close to Aldabra.

Phaethon rubricauda rubricauda Boddaert Red-tailed Tropicbird

Both Betts (1940, 504) and Vesey-FitzGerald (1941, 530) state that it breeds on Aldabra, but give no details. The latter author also states that it breeds on Cosmoledo. It has been collected on Assumption (Ridgway 1895, 522; Nicoll 1906, 697), and according to Ridgway, Abbott found it breeding there (and on Gloriosa). Dupont (1907) lists it from throughout the archipelago. Gaymer informs me that he found a population probably numbering some hundreds, mainly along the northern part of the lagoon, breeding on small islets under rock ledges or bushes: he found a nest with one egg on November 18. Stoddart tells me that he saw a number on Aldabra when he was there in September and October 1966.

Phaethon lepturus lepturus Daudin White-tailed Tropicbird

Collected by Abbott and by Voeltzkow on Aldabra (Ridgway 1895, 532, under the name P. candidus; and Berlepsch 1899, 496, under P. flavirostris). Morris saw a pair there in January 1962, and 20 were seen in all in March 1964 (Bourne 1966).

Sula abbotti Ridgway Abbott's Booby

There is no record of this species from Aldabra, and it is only known from Assumption and from Christmas Island (near Java). Unfortunately the breeding colony on Assumption was wiped out by labourers employed on guano extraction, and there is no record of its occurrence there since 1936 (Betts 1940, 502). Vesey-FitzGerald (1941, 52) in fact gives the year of its final extirpation as 1926.

Sula dactylatra melanops Heuglin Blue-faced Booby

The only evidence of its occurrence on Aldabra is from Morris (1963), who saw both adults and immature birds. It has been collected on Assumption, while Abbott found a few breeding (Ridgway 1895, 520; Nicoll 1906, 697, under the name S. cyanops). Vesey-FitzGerald (1941, 521) doubted if it still bred on Assumption, due to the depredations of the guano labourers, though he also gave several islands on Cosmoledo Atoll as breeding localities. Bourne (1966) records a few seen on Cosmoledo and Assumption.

Sula sula rubripes Gould   Red-footed Booby

Collected on Aldabra (Ridgway 1895, 531; Berlepsch 1899, 495, under the name S. piscatrix), where Abbott found it very abundant. Nicoll (1906, 704) also found it abundant; likewise on Assumption, where he collected two specimens and saw nests with young. There are also specimens in the British Museum collected on Aldabra in October 1906. Vesey-FitzGerald (1941, 522) records nesting on islets in the lagoon of Aldabra, various islands in the Cosmoledo lagoon, and, before the start of guano extraction, on Astove and Assumption, but gives no details. According to Dawson (1966a, 6), it breeds in mangroves on the northern rim of Aldabra, and in mangroves on the inner edges of the islands of Cosmoledo atoll, the nests being made of twigs. Bourne (1966) records three in all seen on Cosmoledo, and thousands of birds, probably mostly this species, seen feeding 10 miles to the north of Aldabra. Stoddart tells me that it was plentiful on Aldabra when he was there in September and October 1966, but in much smaller numbers than the Frigatebirds.

Sula leucogaster Boddaert   Brown Boody

One was seen off Aldabra in March 1964 (Bourne 1966). No further evidence has been traced of the occurrence of this species anywhere in the archipelago, though it breeds in the Amirantes (Vesey-FitzGerald 1941, 521; Ridley and Percy 1958, 19, 30).

Fregata minor aldabrensis Mathews   Greater Frigatebird
Fregata ariel iredalei Mathews   Lesser Frigatebird

It is convenient to consider these two species together. Abbott collected F. minor on Aldabra, and found colonies of many thousands, with eggs plentiful in November (Ridgway 1895, 522). He apparently saw both species, since there is mention of "all gradations of size between the two forms". It was evidently also F. minor which Voeltzkow collected, referred to by Berlepsch (1899, 495) as F. aquila. Nicoll (1906) makes no mention of frigatebirds on Aldabra, but saw F. aquila on Assumption, presumably also referring to F. minor. Vesey-FitzGerald (1941, 530) states that both species breed on Aldabra and Cosmoledo. Thousands of frigatebirds "of two sizes" were seen on Aldabra in March 1964 (Bourne 1966), and Stoddart informs me that they nest in very large numbers on the lagoon side of Middle Island, especially near East Channel. He also (Stoddart and Wright 1967a, 1175) describes them diving to drink on the wing at freshwater pools on South Island. Dupont (1907) lists both species from throughout the archipelago.

Lowe (1924, 308, 312) gives details of further specimens from Aldabra, in the British Museum and in the Rothschild collection at Tring. Those which were at Tring are presumably now in the American Museum of Natural History, including the holotypes of aldabrensis and iredalei (Hartert 1925, 275). The only specimens from Aldabra traced in the British Museum are the two of aldabrensis mentioned by Lowe.

Larus fuscus Linnaeus   Lesser Black-backed Gull

Dawson (1966a, 8) reports a single bird seen from Aldabra, and this appears to be the only record from the Malagasy Region. Either this species or the southern L. dominicanus has been recorded from Beira, in coastal Mozambique (Benson 1948, 151; Worth 1960, 173). But except in the hand, these two cannot be certainly distinguished from each other. Fuscus is much the more likely on Aldabra.

Hydroprogne caspia Pallas   Caspian Tern

There is no record from Aldabra, but this species is mentioned on the strength of sight-records, both during October, from Astove and Cosmoledo (Vesey-FitzGerald 1941, 527).

Sterna albifrons Pallas   Little Tern

Dupont (1907, under the name Sterna minuta) lists this species from throughout the archipelago. Dupont's records of S. balaenarum may also refer to S. albifrons. Bourne (1966) records that "thirty small terns that might have been" this species were seen off Assumption on 17 March. Gaymer informs me that he saw perhaps a hundred in November along the northern coast of Aldabra, and rarely in the lagoon, and that it is locally reported to breed.

Sterna sumatrana mathewsi Stresemann   Black-naped Tern

Collected on Aldabra (Ridgway 1895, 526; Berlepsch 1899, 496; Nicoll 1906, 704; in all these references under the name S. melanauchen). Thirty seen there in March 1964, likewise three on Assumption (Bourne 1966).

Sterna anaethetus antarctica Lesson   Bridled Tern

There is no record from Aldabra, though Vesey-FitzGerald (1941, 526) states that eggs have been found on limestone islets in Cosmoledo atoll in October.

Sterna fuscata Linnaeus   Sooty Tern

"Rare in Aldabra", not collected (Abbott, in Ridgway 1895, 496); one specimen collected by Voeltzkow on Aldabra (Berlepsch 1899, 496) (both notes under the name S. fuliginosa). Vesey-FitzGerald (1941, 525) states that it breeds on Wizard Island, Cosmoledo Atoll.

Thalasseus bergii thalassinus (Stresemann) Crested Tern

Abbott found it common on Aldabra, but did not collect a specimen (Ridgway 1895, 526, under the name Sterna bernsteini). Morris (1963) saw terns there which he thought were the next species, T. bengalensis, but were perhaps bergii. Gaymer reports frequently seeing it feeding at Aldabra, in shallow water over the outer reef or in the lagoon, sometimes in small groups, and states that it is locally reported to breed. Dupont (1907) lists both Sterna bernsteini and bergii from throughout the archipelago, but presumably refers to the one species only, now known as T. bergii. There is also a possible record of three seen on Astove (Bourne 1966). Benson (1960a, 45) collected specimens in non-breeding dress in the Comoros during August-November, and records one in breeding dress from Gloriosa, 10 March.

Thalasseus bengalensis par (Mathews and Iredale) Lesser Crested Tern

There is no certain record from Aldabra or elsewhere in the archipelago, though Abbott collected a specimen on Gloriosa (Ridgway 1895, 524, under the name Sterna media), and there are also specimens from the Comoros (Benson 1960a, 45).

Anous stolidus pileatus (Scopoli) Common Noddy

Collected by Abbott on Aldabra, and breeding in thousands on small islets in the lagoon (Ridgway 1895, 527). Also collected on Aldabra by Voeltzkow (Berlepsch 1899, 496). Seen by Morris (1963), and hundreds seen in March 1964 (Bourne 1966). Stated by Vesey-FitzGerald (1941, 528) to breed on Aldabra (and Cosmoledo), though no details are given. Listed by Dupont (1907) from throughout the archipelago.

Gygis alba monte Mathews Fairy Tern

Collected by Abbott on Aldabra, where common (Ridgway, 1895, 527), and also collected there by Voeltzkow (Berlepsch 1899, 496). Seen by Morris (1963), and hundreds seen in March 1964 (Bourne 1966). Listed by Dupont (1907) from Aldabra, Assumption and Astove.

4. THE LAND BIRDS: THEIR STATUS, ORIGINS AND TRENDS OF VARIATION

Status

Of the 16 species considered in Section 3(1)(a), only one, the drongo Dicrurus aldabranus, is considered to be a full species, endemic to Aldabra. The following are well marked subspecies, also endemic: Threskiornis

aethiopica abbotti (the species is only otherwise known in the Malagasy Region from Madagascar); Dryolimnas cuvieri aldabranus (the species is known also from Madagascar, Mauritius, and the remainder of the Aldabra archipelago, but only still survives on Madagascar and on Aldabra); Caprimulgus madagascariensis aldabrensis (the species is only otherwise known from Madagascar); and Foudia eminentissima aldabrana (the species is only otherwise known from Madagascar and the Comoros).

Other well-marked subspecies are: Butorides striatus crawfordi (known also from Assumption); Streptopelia picturata coppingeri (known also from Assumption and Gloriosa, the Aldabra birds being smaller); and Nectarinia sovimanga aldabrensis (admittedly there is a rather similar subspecies, N. s. abbotti, on Assumption, but these two are distinct enough from any other subspecies, including N. s. buchenorum, of Cosmoledo). Butorides striatus has an almost cosmopolitan distribution, Streptopelia picturata is widespread in the Malagasy Region, while Nectarinia sovimanga occurs also in Madagascar and on Gloriosa.

Two further subspecies endemic to Aldabra, but only certainly distinguished by their smaller size, are Falco newtoni aldabranus and Alectroenas sganzini minor. The former occurs also in Madagascar, the latter in the Comoros. Yet other, poorly marked, endemics are: Centropus toulou insularis (differing from C. t. toulou of Madagascar only by its longer tail and average longer wing-length, with C. t. assumptionis intermediate); Hypsipetes madagascariensis rostratus (differing from the populations of Madagascar, the Comoros and Gloriosa by a rather slight color-difference); and Zosterops maderaspatana aldabrensis (showing minor differences in colour and proportions from Z. m. maderaspatana of Madagascar and Gloriosa, and perhaps also Cosmoledo and Astove).

Egretta garzetta assumptionis has been separated on material from Aldabra and Assumption as having a longer bill than has E. g. dimorpha of Madagascar, but is not worth formal recognition. Finally, there are two species the Aldabra populations of which are indistinguishable. Ardea c. cinerea occurs in Europe, Asia, Africa, the Comoros, the Aldabra archipelago and the Amirantes, with A. c. firasa in Madagascar, while the populations of Tyto alba affinis inhabiting Madagascar, the Comoros and Aldabra differ from those of Africa merely by average larger size. Nor is there any evidence that any of the species whose status is uncertain (Section 3(1)(c)) show any peculiarity.

The status of the land birds proved to breed on Aldabra presents an interesting range, from one "good" endemic species and several well-marked endemic subspecies down to two in which no variation at all can be discerned.

Origins

In the Comoros, Benson (1960b) found the land avifauna to be mainly of Madagascar origin, though with some African elements. The Madagascar influence is proportionately even more preponderant on Aldabra, still more remote from Africa. The only claim to any African affinity arises in the case of Ardea c. cinerea, in any event not a land bird in the strict sense that most

of the other 15 species in Section 3(1)(a) are. The only other one not having at least an ultimate Madagascar origin is Butorides striatus crawfordi. Both this, and the populations of the Mascarene Islands and of the Comoros, appear to be of Asiatic origin, those of Madagascar and the Seychelles of African. B. s. crawfordi is again not a land bird in the strict sense, and an Asiatic derivation need not tax the imagination.

The following species, for none of which is there any definite record from the Comoros,[1] could have colonised Aldabra from Madagascar via Gloriosa and the islands to the east in the Aldabra archipelago: Egretta garzetta, Threskiornis aethiopica, Falco newtoni, Dryolimnas cuvieri, Centropus toulou, Caprimulgus madagascariensis, and Nectarinia sovimanga. This is all the more likely in the case of E. garzetta, D. cuvieri and N. sovimanga, recorded from throughout the archipelago, while C. toulou is also known for Assumption. This route may also have been used by Streptopelia picturata and Zosterops maderaspatana, the populations of which on these intervening islands are very similar to those of Aldabra.

Alectroenas sganzini is only otherwise known from the Comoros, where it may have originated after an earlier colonisation by Alectroenas stock from Madagascar. Tyto alba, Hypsipetes madagascariensis and Foudia eminentissima, also only known in the Aldabra archipelago from Aldabra, but occurring throughout the Comoros, are probably also of proximate Comoro (ultimate Madagascar) origin.

The origin of Dicrurus aldabranus is more obscure, though it is presumably Madagascar-derived. Possibly it arrived via Gloriosa and the other islands in the archipelago, where however the Dicruridae are unrepresented. There is a different species on each of the Comoros except for Moheli, where again the family is unrepresented. It may have been one of the earliest colonisers - it is considered to have attained specific rank - and possibly arrived before the frontal feathers of D. forficatus of Madagascar were as developed as they now are.

Trends of Variation

The most pronounced general trend in variation is towards small size, as shown by wing-length. Thus on Aldabra Butorides striatus, Alectroenas sganzini, and Streptopelia picturata are all smaller than in the Comoros, as is Falco newtoni than in Madagascar and likewise to some extent Zosterops maderaspatana. F. araea, the representative of newtoni in the Seychelles, is still smaller than is newtoni on Aldabra. Streptopelia picturata has become still smaller in the Seychelles too, while Butorides striatus is about the same size there as on Aldabra. On the other hand, Alectroenas pulcherrima of the Seychelles is larger than A. sganzini on Aldabra, and almost as large as that species is in the Comoros. With the exception of A. pulcherrima, these cases fall into line quite well with Bergmann's Rule, the effect of which has probably been accentuated by isolation. But Caprimulgus madagascariensis, which might

[1] Except for one record of F. newtoni on Anjouan as a stray.

also be expected to be smaller on Aldabra than in Madagascar, is larger. It has already been suggested that it may show an incipient tendency to gigantism in isolation. The same may apply to Nectarinia dussumieri in the Seychelles, considerably larger than N. sovimanga, from which it may have been derived long ago.

The striking reduction in wing-length in Dryolimnas cuvieri is not considered to be a reflection of reduction in size so much as in powers of flight, presumably the result of a lack of any natural enemies. The havoc caused by introduced enemies has been mentioned. D. c. aldabranus is almost flightless, while D. c. abbotti of Assumption, now extinct, was well on the way to this stage.

Compared to the Comoros, where (Benson 1960a, 10) the annual rainfall probably nowhere averages much less than 1000 mm. (about 40 inches), and around Mount Karthala, Grand Comoro, exceeds 5000 mm. (about 125 inches), there is a distinct tendency to reduction of melanin, often resulting in an increase of pallor. This is well shown by Streptopelia picturata and Foudia eminentissima. The pallor on the underside of Butorides striatus and brownish tone in Hypsipetes madagascariensis may be due to the same cause. In comparison with Madagascar, this may also apply to Zosterops maderaspatana, yellower above, and Caprimulgus madagascariensis, paler on the crown and scapulars. Nectarinia sovimanga, on Assumption and Cosmoledo as well as on Aldabra, shows a reduction of the olive and yellowish tones, brightest in Madagascar excepting the arid south-west. But it is puzzling to find an extension of black in males in the Aldabra archipelago. This is most marked on Cosmoledo, where by contrast reduction of the olives and yellows is also most marked. In N. dussumieri of the Seychelles these tones are only slightly apparent in juveniles. But perhaps the best example of reduction of melanin is in the immature Dicrurus aldabranus, grey above and white below instead of wholly black except for mere fringes of white on the underside as in D. forficatus of Madagascar and adsimilis of Africa. The almost wholly white feathering on the head of the young Threskiornis aethiopica abbotti may also be the effect of this influence.

Finally, an increase in length of bill, a characteristic of many island populations (see for example Grant 1965), is apparent to some extent in Dryolimnas cuvieri aldabranus. Yet in Nectarinia sovimanga it has shortened, the opposite to N. notata in the Comoros as compared to Madagascar (Benson 1960a, 92). Foudia eminentissima aldabrana has a relatively heavy bill, possibly in adaptation to a seed rather than an insect diet.

5. THE LAND BIRDS: COMPOSITION OF SPECIES

Table 9 shows the occurrence of the various species of land birds in the Aldabra archipelago, drawn up from Section 3(1)(a), with the addition of Cisticola cherina, and from Section 3(1)(c) of Corvus albus. Cosmoledo and Astove have been much less studied than Aldabra and Assumption, especially Aldabra. Nevertheless the list is probably reasonably complete. No record at

all of the first two species in the table has been traced from Cosmoledo or Astove, though it is likely that they do both occur, and may well breed. Some idea of the areas of the four islands can be obtained from Watson, Zusi and Storer (1963, 191). As might be expected from its relatively large land area (60 square miles), Aldabra has easily the largest number of species.

Moreau (1966, 345–357) considered the avifauna of the Comoros, but not that of Aldabra. A few comparisons between the Aldabra list and that for Grand Comoro in Benson (1960a, 17), slightly the nearest of the four Comoros to Aldabra, are worth while. Grand Comoro is of course far larger and higher, having an area of 380 square miles and rising to 7874 feet (for areas and altitudes of the four Comoros, see Watson, Zusi and Storer, 1963, 201). Nevertheless, Moheli, the smallest of the Comoros, area 84 square miles only and not rising higher than 2950 feet, is almost as rich in species as Grand Comoro (Benson 1960a, 17), having 34 as against Grand Comoro's 35, and Aldabra's 16.

Due no doubt to lack of development, Aldabra has none of the following four introduced species, occurring on Grand Comoro and fairly general in the Comoros as a whole: Numida meleagris, Agapornis cana, Acridotheres

Table 9. List of land birds breeding in the Aldabra Archipelago

'X' indicates that the species has been proved, or may be assumed, to breed on the island in question. A bracketed 'X' indicates that breeding is likely but cannot be assumed.

	Aldabra	Assumption	Cosmoledo	Astove
Ardea cinerea	X	(X)	(X)	(X)
Butorides striatus	X	(X)	(X)	(X)
Egretta garzetta	X	(X)	(X)	(X)
Threskiornis aethiopica	X			
Falco newtoni	X			
Dryolimnas cuvieri*	X	X	X	X
Alectroenas sganzini	X			
Streptopelia picturata	X	X		
Centropus toulou	X	X		
Tyto alba	X			
Caprimulgus madagascariensis	X			
Hypsipetes madagascariensis	X			
Cisticola cherina			X	X
Dicrurus aldabranus	X			
Corvus albus	(X)	X		
Nectarinia sovimanga	X	X	X	(X)
Zosterops maderaspatana	X		X	X
Foudia eminentissima	X			

*Extinct except on Aldabra.

tristis, or Passer domesticus. Foudia madagascariensis may also owe its presence in the Comoros to an artificial introduction. Nor has it been established on Aldabra, and the nearest approach to a species associated with human activity is Corvus albus, which in any case is not certainly known to breed there, even though it does on Assumption.

Nor has Aldabra any of the 10 African-derived species found on Grand Comoro, and mostly general in the Comoros, no doubt because it is more remote from Africa. Lack of suitable habitat might explain the absence of such Madagascar-derived species as Circus spilonotus and Saxicola torquata, associated with open grasslands (Cisticola cherina, unknown in the Comoros, also associated with this type of habitat, occurs on Cosmoledo and Astove), or Coracopsis nigra, Chaetura grandidieri and Coracina cinerea, associated with heavy forest (Corasopsis nigra is known also from Praslin, in the Seychelles). Yet Alectroenas sganzini and Foudia eminentissima, mainly forest dwellers in the Comoros, have both colonised Aldabra. Cypsiurus parvus, occurring at lower altitudes throughout the Comoros, may have failed to colonise Aldabra because of a paucity of introduced coconut palms, providing suitable nesting sites. Two other species whose presence might be expected are Alcedo vintsioides and Terpsiphone mutata, both occurring throughout the Comoros. So far as the former is concerned, possibly there is a lack of suitable banks for burrowing of nesting holes, while it may be noted that the genus Terpsiphone is represented in the Seychelles.

Of the first four species listed from Aldabra in Table 9, only Butorides striatus is on the Grand Comoro list. The absence of the other three (the Egretta and Threskiornis are absent throughout the Comoros) may be due to a paucity or lack of suitable habitat, which may also explain the absence of Dryolimnas cuvieri (also absent throughout the Comoros). As already suggested in Section 3(1)(a), Falco newtoni, Centropus toulou and Caprimulgus madagascariensis, all present on Aldabra but completely unknown in the Comoros (except for one record of the first named) may have failed to colonise the latter because originally they were too heavily forested.

6. SUMMARY

1. The history of ornithological exploration of Aldabra is outlined.
2. So far as is possible from existing knowledge, the status of every species of bird known on Aldabra is assessed in a systematic list, divided into two categories, land birds and sea birds.
3. Special attention is paid to the 16 known resident land birds, derived almost entirely ultimately from Madagascar, either via Gloriosa and the islands immediately to the south-east of Aldabra (Astove, Cosmoledo and Assumption) or via the Comoros.
4. One form, a drongo Dicrurus aldabranus, is considered to have attained specific rank, and there are a number of well-marked subspecies. In only two cases is there no apparent variation at all. Trends of variation include a strong tendency to small size in several species in comparison with Madagascar and/or the Comoros. On the other hand, a nightjar Caprimulgus madagascariensis has become somewhat larger than in Madagascar. The

other most marked tendency is a reduction of melanin, often resulting in an increase in pallor, and perhaps associated with a relatively dry climate.

5. A special case is that of a rail Dryolimnas cuvieri, which has become almost flightless, probably due to a lack of natural enemies. But due to the introduction of predators, its continued existence is precarious, and it is already extinct on Assumption, Cosmoledo and Astove.
6. The numbers of land birds on Aldabra, Assumption, Cosmoledo and Astove are listed in a table. Aldabra, the largest in area, has easily the highest number. The Aldabra list is compared with one from Grand Comoro. It lacks all of the African-derived species on Grand Comoro, nor has it any introduced species. But there are two herons and an ibis not on the Grand Comoro list, and a falcon, coucal and nightjar unknown in the Comoros generally, perhaps originally too heavily forested for their occurrence.
7. Various palaearctic migrants, mostly shore birds, have been recorded from Aldabra. Two species have also been recorded as visitors from Madagascar, and which also visit Africa. Other species in both these categories which may also occur are listed.
8. Among land birds of uncertain status, there is a flamingo, Phoenicopterus ruber. It appears not to be a distinct subspecies, and it is still uncertain whether it ever breeds on Aldabra. It is possible that there is a breeding colony of the Crab Plover Dromas ardeola. The nearest definitely known colony is in Somaliland.
9. Aldabra is important as a breeding area for various sea birds, including very large numbers of two frigatebirds, Fregata minor and ariel, a booby Sula sula, and noddy Anous stolidus.

7. REFERENCES

An asterisk * indicates a work devoted entirely, or containing special reference, to Aldabra.

Alexander, W. B. 1955. Birds of the ocean. London.

Bendire, C. 1894. Description of nests and eggs of some new birds, collected on the island of Aldabra, north-west of Madagascar, by Dr W. L Abbott. Proc. U.S. Nat. Mus. 17, 39-41.

Benson, C. W. 1948. Notes from a sea voyage: December 1946 - January 1947. Ostrich, 19, 150-151.

Benson, C. W. 1953. A check list of the birds of Nyasaland. Blantyre and Lusaka.

Benson, C. W. 1960a. The birds of the Comoro Islands. Ibis, 103b, 5-106.

Benson, C. W. 1960b. Les origines de l'avifaune de l'Archipel des Comores. Mém. Inst. scient. Madagascar, Sér. A, 14, 173-204.

*Benson, C. W. 1963a. Notes on some specimens mainly from Aldabra. Bull. Brit. Ornithol. Club, 83, 13-15.

Benson, C. W. 1963b. The breeding seasons of birds in the Rhodesias and Nyasaland. Proc. 13th Internat. Ornithol. Cong., 623-639.

Benson, C. W. 1964. Some intra-African migratory birds. Puku, Occas. Papers Dept. Game and Fish. N. Rhodesia, 2, 53-66.

Benson, C. W. and Roux, F. 1967. Deux records méconnus des Seychelles. Oiseau, 37, in press.

*Berlepsch, H. von. 1899. Systematisches Verzeichnis der von Dr Alfred Voeltzkow in Ost-Afrika und auf Aldabra (Indischer Ocean) gesammelten Vogelbälge. II. Vögel von der Insel Aldabra. Abband. Senckenb. naturf. Gesellsch. 21, 489-496.

Berlioz, J. 1946. Faune de l'Empire français. 4. Oiseaux de la Réunion Paris.

Berlioz, J. 1949. L'albinisme du plumage chez les Ardéidés. Oiseau, 19. 11-30.

Betts, F. N. 1940. The birds of the Seychelles. II. The sea birds - more particularly those of Aride Island. Ibis, ser. 14, 4, 489-504.

Blackman, R. 1965. Bristol University Seychelles Expedition. 7. Biological control. Animals, 7(3), 72-76.

*Boulton, F. R. P. 1960. Bird notes of a visit to islands in the Seychelles and adjacent groups north of Madagascar. Sea Swallow, 13, 48-50.

*Bourne, W. R. P. 1966. Observations on islands in the Indian Ocean. Sea Swallow, 18, 40-43.

Brown, H. D. 1957. The breeding of the Lesser Flamingo in Mweru Wantipa, Northern Rhodesia. Ibis, 99, 688-692.

Coppinger, R. W. 1883. Cruise of the "Alert". Four years in Patagonian, Polynesian, and Mascarene waters (1878-82). London.

(Coppinger, R. W. and others.) 1884. Report on the zoological collections made in the Indo Pacific Ocean during the voyage of H.M.S. 'Alert' 1881-2. London: British Museum (Natural History).

*Dawson, P. 1966a. A survey of the sea birds of the Seychelles Islands. Ool. Rec. 40, 1-11.

Dawson, P. 1966b. The validity of Bubulcus ibis seychellarum. Ool. Rec. 40, 35-36.

Dowsett, R. J. 1965. The occurrence of the Yellow Wagtail Motacilla flava flavissima in central Africa. Ostrich, 36, 32-33.

*Dupont, R. 1907. Report on a visit of investigation to St Pierre, Astove, Cosmoledo, Assumption and the Aldabra Group of the Seychelles Islands. Mahé, Seychelles.

*Fryer, J. C. F. 1911. The structure and formation of Aldabra and neighbouring islands - with notes on their flora and fauna. Trans. Linn. Soc. London, Ser. 2, Zool. 14 (Percy Sladen Expedition Reports, 3), 397-442.

*Gaymer, R. 1966. Aldabra - the case for conserving this coral atoll. Oryx, 8(6), 348-352.

Grant, C. H. B. and Mackworth-Praed, C. W. 1933. On the relationship, status and range of Egretta garzetta, Demigretta gularis, D. schistacea, D. asha, and D. dimorpha, a new subspecies, and the correct type-locality of Egretta garzetta. Bull. Brit. Ornithol. Club, 53, 189-196.

Grant, P. R. 1965. The adaptive significance of some size trends in island birds. Evolution, 19, 355-367.

Griveaud, P. 1960. Une mission de recherche de l'I.R.S.M. au Lac Ihotry. Nat. malgache, 12, 33-41.

*Günther, A. 1879. On the occurrence of a land rail (Rallus) in the island of Aldabra. Ann. Mag. Nat. Hist. Ser. 5, 3, 164-168.

Hartert, E. 1925. Types of birds in the Tring Museum. Nov. Zool. 32, 259-276.

Irwin, M. P. Stuart and Benson, C. W. 1966. Notes on the birds of Zambia: 2. Arnoldia (Rhodesia), (37) 2, 21pp.

Loustau-Lalanne, P. 1962. Land birds of the granitic islands of the Seychelles. Seychelles Soc. Occas. Pub. 1.

Lowe, P. R. 1924. Some notes on the Fregatidae. Nov. Zool. 31, 299-313.

McLachlan, G. R. and Liversidge, R. 1957. Roberts' Birds of South Africa. Cape Town.

Milon, P. 1959. Observations biologiques sur Egretta garetta dimorpha à Madagascar. Ostrich, Suppl. 3, 250-259.

Moreau, R. E. 1957. Variation in the western Zosteropidae (Aves). Bull. Brit. Mus. (Nat. Hist.), Zool., 4(7), 309-433.

Moreau, R. E. 1960. The Ploceine weavers of the Indian Ocean islands. Journ. f. Ornithol. 101, 29-49.

Moreau, R. E. 1964. Article 'Malagasy Region' in Thomson, A. L. (editor), New Dictionary of Birds. London and New York.

Moreau, R. E. 1966. The bird faunas of Africa and its islands. New York and London.

*Morris, R. O. 1963. The birds of some islands in the Indian Ocean. Sea Swallow, 16, 68-76.

Newton, E. 1863. Notes of a second visit to Madagascar. Ibis, 5, 333-350, 450-461.

Newton, E. 1867. On the land-birds of the Seychelles archipelago. Ibis, Ser. 2, 3, 335-360.

*Nicoll, M. J. 1906. On the birds collected and observed during the voyage of the 'Valhalla', R.Y.S., from November 1905 to May 1906. Ibis, Ser. 8, 6, 666-712.

*Nicoll, M. J. 1908. Three voyages of a naturalist, being an account of many little-known islands in three oceans visited by the 'Valhalla'R.Y.S. London.

*Penny, M. 1965. Bristol University Seychelles Expedition. 5. The birds of Aldabra. Animals, 7(15), 409-411.

Rand, A. L. 1936. The distribution and habits of Madagascar birds. Bull. Amer. Mus. nat. Hist. 72, 143-499.

Rand, A. L. 1960. Family Pycnonotidae, in Mayr. E. and Greenway, J.C. (editors), Check-list of birds of the world, 9. Cambridge, Massachusetts.

Reichenow, A. 1900. Die Vögel Afrikas, I. Neudamm.

*Ridgway, R. 1893. Descriptions of some new birds collected on the islands of Aldabra and Assumption, northwest of Madagascar. Proc. U.S. Nat. Mus. 16, 597-600.

*Ridgway, R. 1894a. Note on Rougetius aldabranus. Auk, 11, 74.

*Ridgway, R. 1894b. Descriptions of some new birds from Aldabra, Assumption and Gloriosa Islands, collected by Dr W. L. Abbott. Proc. U.S. Nat. Mus. 17, 371-373.

*Ridgway, R. 1895. On birds collected by Dr W. L. Abbott in the Seychelles, Amirantes, Gloriosa, Assumption, Aldabra, and adjacent islands, with notes on habits, etc., by the collector. Proc. U.S. Nat. Mus. 18, 509-546.

Ridley, M. W. and Percy, R. 1958. The exploitation of sea birds in the Seychelles. Colonial Res. Studies, 25. London.

Rountree, R. R. G., Guérin, R., Pelte, S., and Vinson, J. 1952. Catalogue of the birds of Mauritius. Mauritius Inst. Bull. 3(3), 155-217.

Rudebeck, G. 1963. Aves III. South African Animal Life, 9, 418-516.

*Sclater, P. L. 1871. Description of a new species of dove from the coral-reef of Aldabra. Proc. zool. Soc. London, 1871, 692-693.

*Stoddart, D. R. and Wright, C. A. 1967a. Ecology of Aldabra atoll. Nature, 213, 1174-1177.

*Stoddart, D. R. and Wright, C. A. 1967b. Geography and land ecology of Aldabra Atoll, Southwest Indian Ocean. Atoll Res. Bull. 118.

Vaurie, C. 1949. A revision of the bird family Dicruridae. Bull. Amer. Mus. nat. Hist. 93(4), 199-342.

Vaurie, C. 1959. The birds of the palaearctic fauna. Passeriformes. London.

*Vesey-FitzGerald, D. 1940. The birds of the Seychelles. I. The endemic birds. Ibis, ser. 14, 4, 480-489.

*Vesey-FitzGerald, D. 1941. Further contributions to the ornithology of the Seychelles Islands. Ibis, ser. 14, 5, 518-531.

*Voeltzkow, A. 1897. Einleitung: Madagaskar, Juan de Nova, Aldabra. Abhand. Senckenb. naturf. Gesellsch. 21, 1-76.

*Voeltzkow, A. 1917. Reise in Ostafrika. Wissensch. Ergebn. 3. Stuttgart.

*Watson, G. E., Zusi, R. L. and Storer, R. E. 1963. Preliminary field guide to the birds of the Indian Ocean. Washington.

White, C. M. N. 1951. Systematic notes on African birds. Ibis, 93, 460-465.

White, C. M. N. 1965. A revised check-list of African non-passerine birds. Lusaka.

Williams, J. G. 1953a. Revision of Cinnyris sovimanga: with description of a new race. Ibis, 95, 501-504.

Williams, J. G. 1953b. On the status of the Seychelles sunbirds Cyanomitra dussumieri and Cyanomitra mahei. Ibis, 95, 545-546.

Witherby, H. F., Jourdain, F. C. R., Ticehurst, N. F., and Tucker, B. W. 1941. The handbook of British birds, 3. London.

Worth, C. Brooke. 1960. Notes on sea birds in harbours of Portuguese East Africa. Ostrich, 31, 173-174.

Chapter 5

OBSERVATIONS ON THE BIRDS OF ALDABRA IN 1964 AND 1965

R. Gaymer

Department of Zoology, Bristol University

1. GENERAL OBSERVATIONS

Birds are conspicuous on Aldabra, for although the number of species is small, the species themselves are represented by large populations. This paper presents observations on the natural history of the land birds, together with some notes on the sea and shore birds, obtained during two visits to Aldabra made by the Bristol Seychelles Expedition, the first from 11 November to 14 December 1964, the second from 4 October to 20 November 1965.

Fourteen land birds are considered here, together with the flamingo, which spends much of its time at inland pools. Of these fourteen, only three have apparently not diverged from their Madagascan or Comoran ancestors (Benson 1967). These are the Pied Crow Corvus albus, which is extremely mobile amongst these islands; the Cattle Egret Bubulcus ibis, which seems to be a recent arrival; and the Madagascar Bulbul Hypsipetes madagascariensis. Pied Crows are frequent around the settlement on West Island, and also occur in areas of Mixed Woodland and beach vegetation on South Island. Their total numbers cannot exceed a few hundreds. Cattle egrets have previously been recorded only as rare vagrants, but as elsewhere there has been a recent increase, and at least 100 birds now live on South Island, around Takamaka.

There are no introduced birds on Aldabra apart from the few chickens on West Island, despite the many introduced species in neighbouring island groups. Very large numbers of migrants visit Aldabra, but these are mainly waders, which feed on the lagoon and among the brackish pools in the southeast. A number of vagrant land birds have also been recorded, and are listed by Benson (1967). Only the Broad-billed Roller Eurystomus glaucurus glaucurus may occur regularly, having strayed on migration between Africa and its breeding quarters in Madagascar. The Blue-cheeked Bee-eater Merops superciliosus might be expected, since it has been seen on Cosmoledo (R. Gaymer, October 1), as might the Madagascar Grass-warbler Cisticola cherina, which is common on Cosmoledo and Astove. Four specimens of a barn owl were collected on Aldabra in 1892 and one in 1906, but none have been recorded since, and they must be assumed extinct. They do not appear to differ from the African Tyto alba affinis (Benson 1963), which also occurs in Madagascar and the Comoros.

The main land bird habitats are (1) mixed scrub and woodland covering the interior of South Island, and to a lesser extent West and Middle Islands; (2) Pemphis scrub, which covers most of the rest of the atoll; (3) mangrove communities fringing the lagoon; and (4) the coastal vegetation, which is best developed in the west.

In probable order of abundance the commonest species are the Sunbird, the Fody, the Bulbul and the White-eye. These are omnivorous birds, able to utilise the many flowering shrubs and trees, with which their breeding season is synchronised. Excepting the pigeons, the larger birds are either scavengers with a wide range of foods and feeding sites, such as the Ibis and Pied Crow, or, like the Kestrel, Nightjar, Drongo and Coucal, they are more specialised and feed on lizards or large insects which are in more regular but limited supply. These birds are mostly less numerous, despite their smaller size.

The fruits and seeds of the flowering plants provide a large and continuous food supply for the ground-feeding Turtledove, since germination and decay are

minimal on the dry rocky or sandy ground. Fleshy fruits are much less abundant, and the supply must be very seasonal. This probably explains the rather small numbers of the Comoro Blue Pigeon, which are only common in the southeast, where Ficus and other trees are concentrated. The numbers and distribution of the other birds also correspond with the vegetation types.

1. Mixed Scrub on Platin

Most of the land birds are commonest here, with the exceptions of the Pied Crow and the White-throated Rail, which latter is confined to the mangrove, Pemphis scrub and beaches of Middle Island and Polymnie. The Comoro Blue Pigeon, Madagascar Coucal, Madagascar White-eye, and probably the Madagascar Nightjar are only otherwise found in areas of rich beach vegetation. The White-eye and the Coucal seem particularly dependent on dense cover. Although found inland, the Pied Crow is best considered as a littoral scavenger, and is commonest around the outer coast. Cattle Egrets roost in a large clum of trees at Takamaka, as do the Sacred Ibis and fruit bats.

2. Pemphis Thicket on Champignon

Pemphis appears to provide little food, and it is generally avoided by the birds. The White-throated Rail is an exception. Where mixed woodland is close, the Sunbird and the White-eye are sometimes seen, and the former at least may nest.

3. Mangrove

Mangroves are a major habitat for nesting sea birds, and dense stands of Rhizophora are also inhabited by occasional water birds, and by Drongos, which nest near the edges. Small numbers of Sunbirds occur in open mangrove of this type, and also of Avicennia and other genera, as do Drongos and sometimes Kestrels and Fodies. Sacred Ibis feed in mangrove on the lagoon margins. Turtledoves may nest in mangrove, but this has not been observed. The Flamingos are largely confined to this habitat, which also serves as winter quarters for many migrant waders.

4. The Settlement

The settlement area on West Island is visited by Sunbirds, Bulbuls and White-eyes, but only because it is an area of rich beach vegetation. The Fody and Turtledove exploit the food provided by the kitchens and the feeding of domestic animals, the Fody being especially efficient in competition with chickens for rice. Both species also exploit the many Casuarina trees along the beach, and the Fody breeds in the lower branches. Pied Crows scavenge for offal when possible, but are discouraged. The other birds avoid the settlement.

2. THE LAND BIRDS

Threskiornis aethiopica abbotti Ridgway Sacred Ibis

Because of its large size (70 cm.) and pleasant flesh, this bird is uncommon and is restricted to the more remote parts of South Island, where it is most abundant in well-developed mixed woodland and open mangrove. It feeds in small groups in the lagoon at low tide, or in twos and threes inland (Plate 28). Large numbers roost at Takamaka, where a colony was found nesting over a small tree by the pool (Plate 33). There were 21 nests, built in a mass at a height of 7-10 feet; 17 of the nests contained two eggs, two had one egg, and one had three. The eggs were off-white in colour, stained, and without lustre. By the following day (November 22) a further bird had laid. Over the next five days all the eggs vanished, despite minimal disturbance. Fryer (1911) found a similar colony in which two out of a total of 18 eggs were destroyed, according to him in gaining access to their own individual nests. The nests found in 1964 were about 45 cm. in diameter, composed of twigs, and lined with a small amout of tufts of grass and dead and fresh leaves, none of which were woven. The cavities were shallow. Nicoll (1906) found old nests in mid-March, at which time the young were fully grown.

Reports of feeding include the taking of scraps and turtle offal from around the camps of turtle fishermen, and small crabs and other marine animals. The bill is used to probe for food in the mud of the lagoon and of fresh and brackish pools inland. Many Ibis are also seen searching in leaf litter inland, and may eat lizards, large insects, and some vegetable matter. These birds were once extremely tame, but although all ages are still very inquisitive, only the juveniles now approach to within two or three yards: they are recognisable by their rather shabby appearance, smaller size, and feathered necks.

Phoenicopterus ruber roseus Pallas Greater Flamingo

The flamingos on Aldabra have been variously reported "resident . . . numbers 500 to 1000" or absent, and therefore previously only as migrants in passage. It is clear that they are regularly present at least in the southeast, where they occur in small groups or pairs in the brackish pools amongst the mangroves (Plate 36). There seemed to be about 50 birds at the time of our visit, but they are very shy and difficult to approach. They may breed, but this has not been confirmed. Although the mangroves in the southeast seem to be the main habitat, flamingos have also been reported in the lagoon proper; flying over Middle Island in the east; and over South Island near Dune Jean Louis.

Falco newtoni aldabranus Grote Madagascar Kestrel

This kestrel hunts lizards and rarely hovers, but is otherwise fairly typical. The male is chestnut and black dorsally, with a grey head, and spotted beneath. The female is larger, more spotted, and generally brownish above. The only prey seems to be the lizards Ablepharus and Phelsuma, and possibly some nocturnal geckos. Unlike the Madagascan form, this bird avoids human habitations. It occurs over much of South Island, but since breeding territories

are very large, the total population cannot exceed 100 birds. The only breeding record is one nest at Anse Mais, on the west coast of South Island. It was found on 18 November, in the crown of a coconut palm, at about 25 feet above the ground, and contained a little down and three large young (see Penny 1964, 40). Lizards were being brought to the young by the parents, who also defended the area against Pied Crows, Drongos and Bulbuls. On one occasion a kestrel was observed driving seven Pied Crows away. This behaviour was seen at Takamaka, indicating that breeding may also have been in progress there.

Dryolimnas cuvieri aldabranus (Günther) White-throated Rail

This Rail, the Aldabra form of which is flightless, has head, neck and breast a dull chestnut colour, otherwise the general colour is olive, with the chin and throat of adults white. It appears to be confined to Middle and Polymnie islands, but may also occur on Esprit and Michel in the lagoon. There is no evidence that rails have lived on South Island, although Abbott (in Ridgway 1895) states that they did and had been exterminated by feral cats. Rails were then common around the settlement on West Island, but were rare by 1908 (Fryer 1911) and have not been recorded since. Cats and rats are the most likely cause of their extinction on West Island.

It is possible that these Rails are in some way associated with the large colonies of sea birds which occur in the same areas. Eggs are certainly eaten with speed and efficiency when offered, although large insects and shore crabs may be more important foods in the wild.

Bendire (1894) describes the only nests recorded, collected by Abbott. They were rather loosely constructed from small twigs and plant stems, one at 18 inches above the ground, the other more typically in a cavity in the rock. The first nest was 25 cm. wide and 18 cm. deep, with a cavity measuring 11.5 by 9.5 cm., which meant that the hen sat with only the head protruding. The second nest was composed of finer materials, mainly dried grass, and was concealed behind a tuft of grass. Clutches were 4, 3, 2 and 2. The average size of the eggs was 4.25 x 3.0 cms. The shells were strong, fairly glossy with fine granulations, and of a creamy white colour, sparingly dotted with liver brown, vineaceous and lavender. The marks were heaviest at the larger end. These nests were taken in December, so it is surprising that others on Aldabra at the time have seen no signs of breeding. Abbott (1893) says that a few pairs were breeding in September, but that most did not breed until November-December. Nicoll (1906), who was on Assumption from 11 to 13 March, thought the breeding season of the Rail was over, though he did see several young still covered with black down. On Aldabra, Abbott gives the clutch size as three, rarely four, despite local reports that this is often exceeded. The hen sits very closely and quickly returns once disturbed. In Madagascar the breeding season of this species probably includes October, November, and January to March (Rand 1936).

A startling variety of calls is produced, with the head raised. A drum-like sound, often followed by a long curlew-like whistle, is common, and when excited a series of shrieks and grunts can be produced, which may be used to call the young (Nicoll 1906). Pairs are territorial and fighting has been reported.

Alectroenas sganzini minor Berlepsch   Comoro Blue Pigeon

This medium-sized fruit pigeon is strikingly coloured pale grey and midnight blue, with bare red skin around the eye (Gaymer 1966; Penny 1965, 411). The male has some of the feathers on the head and neck faintly tipped with pink. Juveniles are green with some yellow above, and greenish grey below.

Small groups of blue pigeons are conspicuous in larger trees, and they are also seen flying overhead at some height in ones and twos. They are well distributed in the mixed woodland on South Island and West Island, often revealing their presence by a hoarse 'hoo', repeated four or five times. This is especially characteristic of the male display, in which he hops through the canopy of a tree after a female, cooing, bowing, and raising the plume feathers of the head and neck, often stopping to drive away other birds, including Bulbuls. This display has been regularly observed in November and December, but the testes of two males taken at that time were small (10 x 4 mm.) with little fat. Nesting and rearing may occur in February to March. Young birds have been seen with their parents in March (Nicoll 1906). In the Comoros Benson (1960) collected a female of this species containing an almost fully developed egg on 2 November, while in Madagascar Rand (1936) found that A. madagascariensis breeds from July to March. On Aldabra the nests are probably built in the tops of larger trees inland.

These pigeons eat the fleshy fruits of Ficus sp. (la fouche, banyan) and small flocks are attracted to these and other fruiting trees. Fruits up to 1 cm. in diameter are swallowed whole, many being dropped while feeding. Drinking has not been observed, nor have they been seen on the ground.

Streptopelia picturata coppingeri (Sharpe)   Madagascar Turtledove

This pinkish grey-brown dove, about 30 cm. in length, spends much time on the ground in small groups, searching for seeds, which are the main food. Casuarina seeds are eaten where possible, and some rice and other scraps are eaten at the settlement. In the Comoros some insects are also taken (Benson 1960) but this has not been seen on Aldabra. Small freshwater pools are visited regularly in the morning and evening (at least in the dry season), being approached on the ground, usually in small flocks.

Remarkably little is known about breeding. Abbott (in Ridgway 1895) reports that nesting occurs in mangrove in September to November. This is surprising, since they are now rarely seen in mangrove. Males were observed courting and driving other males away during November and December. In the Comoros, Benson (1960) had evidence of this species breeding in August to November, while in Madagascar Rand (1936) found that the season probably extends at least from July to October. On Aldabra, two white eggs are probably laid on a flimsy platform of twigs in the canopy of a tree, as elsewhere.

Centropus toulou insularis Ridgway   Madagascar Coucal

A large clumsy bird, about 45 cm. long, which includes a long graduated tail and heavy hooked beak. Both male and female have the characteristic call--a descending "tou-lou-lou"--but at different pitches, the male's being

the higher. This call carries very well, and often reveals their presence when the birds are well hidden in the canopy of a tree or in a bush. They are only found in areas of dense mixed vegetation, in which much of their time is spent in search of food. This consists of centipedes, lizards, crickets, and probably grasshoppers, cicadas, mantids, etc. Bird eggs are also eaten, and young may be taken too. Abbott (in Ridgway 1895) reports his belief that small rats are eaten. Food is swallowed whole, being captured mainly on the ground.

Abbott describes the nest, which is oval and very large, with an entrance at one end, by which he presumably means at the side. It is made of loosely interwoven strips of bark, grass, and, where available, coconut leaves. He gives the height as 5 to 8 feet above the ground, although Fryer (1911) describes a nest as "low down" in a bush. Three or four white eggs are laid. The birds are in breeding plumage by October, and pairs can be heard calling together in their large territories. As in Madagascar (Rand 1936), the breeding season of this species probably extends from December to March.

Caprimulgus madagascariensis aldabrensis Ridgway   Madagascar Nightjar

This nightjar is about 24 cm. long, with typical grey and brown cryptic coloration. It is rarely seen, but at night the falling rattle and two-noted cry (with the second note stressed) can commonly be heard inland, especially in the southeast. Abbott (in Ridgway 1895) also reports a "winnowing" cry.

Occasionally a roosting bird may be flushed from the ground during the day. Almost nothing is known of this bird's habits. Abbott reports that beetles were taken at night from around a pile of refuse on West Island. He states that breeding occurs on open ground or sand hills, and found a nest with young in September. Rand (1936) records breeding of this species in Madagascar in August, September and October.

Hypsipetes madagascariensis rostratus (Ridgway)   Madagascar Bulbul

This noisy bird is grey, with an orange bill and a short black erectile crest. It is sometimes in groups of up to a dozen, although a group of two or three is more normal. The song is a harsh, quite complex whistle, but many other sounds are made. Berries and other fruits, flowers, and flower buds form the major part of the diet, but mantids, orthoptera and other large insects are taken when possible, sometimes on the wing.

The breeding season probably extends from November to January, though in the Comoros Benson (1960) gives evidence of breeding starting as early as September, and in Madagascar Rand (1936) gives the season as extending at least from September to January. On Aldabra nesting material was being carried on 27 November, and two nests were collected by Abbott on 22 December and 31 December. These are described by Bendire (1894). They were rather slight, and composed of fine rootlets, small twigs, dry leaves and plant fibres, being lined with finer materials of the same kind, plus dry grasses. They measured 10.4 x 7.2 cm. externally, and 9.5 x 4.5 cm. deep internally. Both were at about 8 feet above the ground, in the crotches of thorny shrubs. One contained two eggs, the other only one, and these averaged 2.48 x 1.77 cm. The shells were close grained, glossy vinaceous pink, profusely spotted and blotched

with different shades of claret brown, vinaceous rufous and lavender, forming a wreath at the larger end.

Dicrurus aldabranus Ridgway   Aldabra Drongo

Adults of this species are black, with a long forked tail and a total length of about 28 cm. The bill is stout and compressed, hooked at the tip, with strong nasal bristles at the base. Immature birds are rather unevenly grey, paler beneath. Drongos are commonly seen in pairs or family parties, sitting conspicuously on bare branches in mixed woodland near mangrove. It is a pugnacious bird, with large territories. The nesting area itself is successfully defended against even Ibis and Grey Herons. Bendire (1894) describes two nests, collected in November and early December. These were very firmly constructed of fine twigs and lined with finer ones, to form a rather shallow cup 7.5 cm. wide and 3.25 cm. deep, the outer dimensions being 14 x 5 cm. Three eggs were rich cream, with scattered spots of cinnamon rufous and brick red, some with one or two lavender dots. There was no lustre, and the markings were heavier at the larger end. Average measurements were 2.65 x 1.9 cm. These nests were built on a horizontal branch of Casuarina, but where this tree is absent, nests are built in mangrove, at a height of 15-20 feet above the ground. Inland, nests may be built in large Ficus and other trees. One such nest was composed mainly of dried sedges, looped over a fork at 18 feet. It was frail in appearance, with a fairly deep cup internally. Spider's web is often incorporated, and this was also noted by Abbott (in Ridgway 1895). Abbott gives the clutch size as three or four.

A nest with one young was seen at the end of November, but it was later found abandoned. Another nest was found on 2 December containing three young. Several family parties were seen in November and December, but none had more than two young, and most had only one, and this may be the usual number reared. Benson (1960) found eggs of D. waldeni on Mayotte in the Comoros in October and November, while Rand (1936) found the breeding season of D. forficatus in Madagascar to be from September to December. Nothing is known about feeding, but related species eat beetles, homoptera, and spiders. The young are fed by both parents on what appeared to be large insects.

Nectarinia sovimanga aldabrensis (Ridgway)   Souimanga Sunbird

This is a typical sunbird, very small (about 11 cm.), with a long downcurved beak. The male has bright metallic coloration, the female and juveniles are dull brownish grey. These birds are very active, and hop continuously through bushes and trees, uttering a frequent high-pitched 'chink'. The males sing loudly in the breeding season, which is prolonged, extending at least from September to January (Abbott in Ridgway 1895). Morris (1963) found eggs in January. Nests are domed, and usually suspended from a branch at 4-12 feet above the ground, or sometimes hung from branches or roots over the edge of a pit in the ground. The nest is begun by fastening streamers of twice or more the final length of the nest to the chosen Pemphis, mangrove, or other branch. Abbott (in Ridgway 1895) describes the formation of an oval mass of nesting material, which the hen then opens out by pushing in her head

and body, later entering the cavity, and finally lining it with feathers. The nest includes bark fibres, grasses, dried marine grass from the beach, down from pods of wild cotton, and many hundreds of feathers. It takes about eight days to build, all the work being done by the female. Vesey-FitzGerald (1940) gives the internal dimensions of a nest on Astove as 10 cm. deep and 8 cm. wide, the entrance being 3.5 x 4.0 cm. Morris (1963) gives the entrance as 4 cm. in a nest about 11.5 cm. across. He describes the eggs as dirty white, mottled with umber. He later found this nest in "tattered ruins". Two nests which were built into a branch, rather than suspended, were also the highest seen, at 10 and 12 feet above the ground. The nesting density is sometimes very high. Eleven nests were counted at Anse Mais in mid-November. Two eggs are laid, and incubation takes 13 days, the sexes sharing the task. The eyes of the young open on the seventh day.

Nectar is sipped with the tubular tongue, sometimes while hovering, but generally while perched. Small flies are eaten in large numbers, with some solid vegetable matter, mainly stamens and other flower parts. All solid food is swallowed in very small pieces. The young are probably fed mainly on insects.

Although no longer so tame that they alight on one's arm (Abbott in Ridgway 1895), the females and juveniles will often inspect an intruder while hovering in front of his face.

Zosterops maderaspatana aldabrensis Ridgway   Madagascar White-eye

This tiny yellow to olive-green bird, with a white ring around the eye, is usually seen in small flocks, which move through the bushes and trees with repeated soft calls, well described by Morris (1963) as a low, rather bell-like 'tee-eep", and an almost continuous low twittering. Although often hard to locate, white-eyes are very common in areas of rich beach vegetation and in the denser parts of the mixed woodland. The diet is mixed, consisting of berries (swallowed whole), small beetles and other invertebrates, nectar taken up with the brush tongue, and buds and flower parts. Food is not taken on the wing.

Breeding takes place from October to December (Abbott in Ridgway 1895). Nests are built at about 6 feet above the ground, slung into a fork at the top of a bush. They form a small deep cup, in which two or three pale blue-green translucent eggs are laid, and are composed of shreds of bark, leaves, grass and small twigs, with little lining. *Casuarina* needles have also been reported.

During courtship pairs can be seen preening each other around the head and neck while sitting side by side on a branch. The male sings, and pairs are territorial, but this is not so apparent as in most of the other birds.

Foudia eminentissima aldabrana Ridgway   Red-headed Forest Fody

This bird is common and conspicuous, especially around the settlement on West Island. The female is somewhat sparrow like, but is more yellow, with dark streaks, and has a more powerful bill. The male in breeding plumage has a vivid orange-scarlet head and breast, with the belly and back yellow and the rump orange. Immature birds resemble the female.

Flocks of breeding adults may be formed while feeding, but this is unusual. Males are strongly territorial, with a characteristic threat display, in which the wings and tail are drooped, and the head, breast and rump feathers puffed out (Plate 35). The intruder is then challenged with a series of wheezing or fizzing calls, and a metallic 'ching-ching'. A female may be so challenged, but on recognition the calls become a series of thin high whistles at about half-second intervals, uttered by one or both sexes. The male then raises his wings high and quivering above his back (in obvious strong contrast with the threat posture) and if accepted mounts and copulates with the crouching female, keeping his wings raised. Copulating was observed in November and December. Territories may be as small as 1000 square yards in groves of larger trees, indicating a possible forest ancestry. Nests may be from 4 to 20 feet high, and if one is destroyed another is built nearby. Mixed woodland is preferred, and Casuarina is used if available. Nests in mangrove are rare. Abbott (in Ridgway 1895) gives the clutch as four, but those he collected were 3, 3, 2 and 2. We observed four nests with eggs: all had three eggs, these being laid in one case on consecutive days, ceasing after the third egg. Abbott also states that nesting is in November, December and January; it probably extends to February or March. The male assists in nest construction but not in incubation. Bendire (1894) describes the nest and eggs. Nests are domed, and are built into the branches of a tree or shrub. They measure 23 x 18 cm., with inner dimensions 7.5 cm. wide and 7.0 cm. deep. The eggs are pale glaucous green, nearer blue, unspotted, with a rather thin glossy shell. They average 2.05 x 1.4 cm. in size.

These fodies feed on seeds, flowers and beetles taken from among bushes and trees, or from the ground. Other small invertebrates may also be taken. Rice and kitchen scraps are eaten at the settlement, and Casuarina seeds wherever found. Abbott reports that unripe maize was eaten if opened by rats, but since the bill is very powerful, they must have been so unfamiliar with maize that they attacked it only when exposed.

3. NOTES ON SEA AND SHORE BIRDS

There have been no studies of the marine birds of Aldabra, apart from a small amount of collecting, and some scattered observations. Benson (1967) has listed the known species. The following notes on sea and shore birds are divided into (1) known breeding species, and (2) unconfirmed breeding species.

1. Breeding Species

Phaëthon rubricauda   Red-tailed Tropicbird

A population probably numbering some hundreds lives mainly along the northern part of the lagoon, breeding on small islets under rock ledges, bushes or tall grass (Plate 31). Nest with egg found on 18 November.

Sula sula   Red-footed Booby

Many thousands breed in colonies scattered amongst the frigate bird camps on Middle Island. Vesey-FitzGerald (1941) describes nesting, and states that

breeding occurs "around September". Some fledged young were seen in November (Plate 30). No dark morphs seem to occur as reported on Gloriosa.

Fregata minor   Greater Frigatebird
Fregata ariel   Lesser Frigatebird

Huge camps containing tens of thousands of these birds occur in the mangrove fringing the lagoon shore of Middle Island. Eggs of both species were present on 7 October, although the season has been given as May to August. Frigates may breed on the Cargados Carajos and Gloriosa, but otherwise the Aldabra colonies supply the entire western Indian Ocean. Vesey-FitzGerald (1941) reports that frigates nest on Cosmoledo but this no longer seems to be the case. The colony reported by Fryer (1911) on West Island, Aldabra, seems also to have gone, probably as a result of human activities. Benson (1960) supposes that frigates breed in the Comoros, but in view of the small numbers seen they may be visitors from Aldabra. Stoddart and Wright (1967) describe frigates diving for water at freshwater pools on the South Island platin.

Butorides striatus   Little Green Heron

A local race, frequent around the west coast, but less common elsewhere. Probably nests, as in the Seychelles (Dawson 1966), over a long period, concentrated in the northwest monsoon, but this requires confirmation.

Egretta garzetta   Little Egret

Many thousands feed in the lagoon at low tide, and elsewhere, and the bird is also seen inland. White morphs outnumber the slate-grey dark morphs by about 7 to 3 (Dawson 1966). Probably breeds in the mangrove, August-September.

Sterna sumatrana   Black-naped Tern

Regularly seen in small numbers in the lagoon. A nest with one egg was seen on 17 November on a small bare island in the lagoon near Polymnie. Eggs have been found in September to November on other island groups (Vesey-FitzGerald 1941).

Anous stolidus   Common Noddy

Thousands occur on small bare islands out in the lagoon, scattered amongst the frigate colonies on Middle Island, and on the cliffs of islands in West Channels. It breeds in cavities and ledges of islets in the lagoon (Vesey-FitzGerald 1941), and probably in the mangrove; the season may be June-August.

2. Unconfirmed Breeding Species

Phaëthon lepturus   White-tailed Tropicbird

Rather more common and widespread than the red-tailed species. Would breed in similar situations.

Sterna albifrons   Little Tern

Perhaps a hundred seen along the northern coast in November, and more rarely in the lagoon. They are locally reported to breed, laying one egg in a sand scrape.

Thalasseus bergii   Crested Tern

Frequently seen feeding in shallow water over the outer reef or in the lagoon, sometimes in small groups. Locally reported to breed, young being taken from the bare low Chalen Islands, near West Channels.

Gygis alba   Fairy Tern

Seen flying in twos and threes in the lagoon. Locally supposed to breed throughout much of the year.

Dromas ardeola   Crab Plover

Flocks of up to several hundred feed on exposed sand and mud over the reef in the west and in the lagoon. Not locally thought to breed.

3. Non-Breeding Migrants, Visitors and Vagrants

The following species occur in large numbers in the creeks and pools of the mangrove around Bras Takamaka and elsewhere, and sometimes around the outer coast and in the lagoon at low tide: Turnstone Arenaria interpres, Whimbrel Numenius phaeopus, Sanderling Crocethia alba. Less common are the Greenshank Tringa nebularia, the Common Sandpiper Actitis hypoleucos, the Curlew Sandpiper Erolia testacea, and the Wood Sandpiper Tringa glareola. The Turnstone is probably the only species present throughout the year.

Other species of sea birds reported include the Sooty Tern Sterna fuscata, the Lesser Black-backed Gull Larus fuscus, and possibly the Blue-faced and Brown Boobies Sula dactylatra melanops and Sula leucogaster (Fryer 1911, and local reports).

4. ACKNOWLEDGEMENTS

I thank the other members of the Bristol Seychelles Expedition, who shared with me the work on which this paper is based, and also those who by their gifts and assistance made the expedition possible, and particularly the World Wildlife Fund for their support.

Dr W. R. P. Bourne and Mr C. W. Benson have read the manuscript and made suggestions. I would also like to express my appreciation of the invaluable Preliminary Field Guide to the Birds of the Indian Ocean by Watson, Zusi and Storer (1963).

5. REFERENCES

Abbott, W. L. 1893. Notes on the natural history of Aldabra, Assumption and Glorioso Islands, Indian Ocean. Proc. U.S. Nat. Mus. 16, 759-764.

Bendire, C. 1894. Description of nests and eggs of some new birds, collected on the island of Aldabra, north-west of Madagascar, by Dr W. L. Abbott. Proc. U.S. Nat. Mus. 17, 39-41.

Benson, C. W. 1960. The birds of the Comoro Islands. Ibis, 103b, 5-106.

Benson, C. W. 1963. Notes on some specimens mainly from Aldabra. Bull. British Ornithol. Club, 83, 13-15.

Benson, C. W. 1967. The birds of Aldabra and their status. Atoll Research Bulletin 118.

Fryer, J. C. F. 1911. The structure and formation of Aldabra and neighbouring islands--with notes on their fauna and flora. Trans. Linn. Soc. London, ser. 2, Zool. 14 (Percey Sladen Expedition Reports, 3), 397-442.

Gaymer, R. 1966. Aldabra--the case for conserving this coral atoll. Oryx, 8, 348-352.

Morris, R. O. 1963. The birds of some islands in the Indian Ocean. Sea Swallow, 16, 68-76.

Nicoll, M. J. 1906. On the birds collected and observed during the voyage of the 'Valhalla', R.Y.S., from November 1905 to May 1906. Ibis, ser. 8, 6, 666-712.

Penny, M. 1965. Bristol University Seychelles Expedition. 5. The birds of Aldabra. Animals, 7(15), 409-411.

Rand, A. L. 1936. The distribution and habits of Madagascar birds. Bull. Amer. Mus. Nat. Hist. 72, 143-499.

Ridgway, R. 1895. On birds collected by Doctor W. L. Abbott in the Seychelles, Amirantes, Gloriosa, Assumption, Aldabra, and adjacent islands, with notes on habits, etc., by the collector. Proc. U.S. Nat. Mus. 18, 509-546.

Stoddart, D. R. and Wright, C. A. 1967. Ecology of Aldabra Atoll. Nature, 213, 1174-1177.

Vesey-FitzGerald, D. 1940. The birds of the Seychelles. I. The endemic birds. Ibis, ser. 14, 4, 480-489.

Vesey-FitzGerald, D. 1941. Further contributions to the ornithology of the Seychelles Islands. Ibis, ser. 14, 5, 518-531.

Chapter 6

BIBLIOGRAPHY OF ALDABRA

D. R. Stoddart

Department of Geography, Cambridge University

This Bibliography of Aldabra must be incomplete, since systematic searching of the literature has yet to be made for Aldabra references in many fields, particularly in history. It concentrates on recent scientific literature, but again, though a fairly intensive search has been made, many items must have been missed. It is likely, however, that no important item pertinent to the ecology of Aldabra has been missed. Specialist papers from the major expeditions are only cited if they contain records from Aldabra, though no attempt has been made to give complete coverage of purely taxonomic papers naming Aldabra species. This Bibliography also contains a number of items which are cited in Chapters 1, 2 and 3 of this Bulletin, but which do not specifically refer to Aldabra, and these are marked with an asterisk*.

Abbott, W. L. 1893. Notes on the natural history of Aldabra, Assumption and Glorioso Islands, Indian Ocean. Proc. U.S. Nat. Mus. 16, 759-764.

Anonymous. 1879. (Aldabra.) Geographischer Monatsbericht: Afrika. Petermanns Mitteil. 25, 362.

Anonymous. (c. 1920). Aldabra: a coral island pot-pourri, dealing with the natural history and physical geography of certain coral islands in the Indian Ocean. Typescript manuscript, 14 chapters separately paginated, totalling 154 p. Copy in Tring Museum, British Museum (Natural History).

Aurivillius, C. 1909. Lepidoptera, Rhopalocera und Heterocera (pars I) von Madagascar, den Comoren und den Inseln Ostafrikas. In A. Voeltzkow, Reise in Ostafrika in den Jahren 1903-1905, Wissensch. Ergebn. 2, 309-348.

Aurivillius, C. 1922. Coleoptera (Cerambycidae) from the Seychelles Islands, Aldabra, and Rodriguez. Ann. Mag. Nat. Hist. Ser. 9, 10, 421-443.

Baker, B. H. 1963. Geology and mineral resources of the Seychelles archipelago. Govt. of Kenya, Ministry of Commerce and Industry, Geol. Surv. Kenya, Mem. 3, 1-140.

*Baker, B. H. and Miller, J. A. 1963. Geology and geochronology of the Seychelles Islands and structure of the floor of the Arabian Sea. Nature, 199, 346-348.

(Baker, J. G.) 1894. Flora of Aldabra Islands. Bull. Misc. Inform. Roy. Bot. Gardens Kew, 1894, 146-151.

Baty, S. C. E. 1896. A report on the Aldabra and Cosmoledo groups of islands. Unpublished report, Library, Royal Botanic Gardens, Kew.

*Baulig, H. 1956. Vocabulaire Franco-Anglo-Allemand de Géomorphologie. Pub. Faculté des Lettres de l'Univ. de Strasbourg, Fasc. 130, 1-230.

Bendire, C. 1894. Descriptions of nests and eggs of some new birds collected on the island of Aldabra, northwest of Madagascar, by Dr W. L. Abbott. Proc. U.S. Nat. Mus. 17, 39-41.

Benson, C. W. 1960. The birds of the Comoro Islands: results of the British Ornithologists' Union Centenary Expedition 1958. Ibis, 103b, 5-106.

Benson, C. W. 1963. Notes on some specimens mainly from Aldabra. Bull. Brit. Ornithol. Club, 83, 13-15.

Benson, C. W. 1967. The birds of Aldabra and their status. Atoll Research Bulletin 118.

(Bergroth, E. Hemiptera (Heteroptera) von Madagaskar, gesammelt von Dr Voeltzkow. Announced for publication in Abhand. Senckenb. naturf. Gesellsch. 27 by Voeltzkow 1902b, 561, who gives a list of 20 species quoted from it; the paper did not appear.)

Berio, E. 1956. Eteroceri raccolti del Dr Carlo Prola durante la spedizione alle isole dell'Africa orientale, con descrizione die specie nuove. Bollettino della Società Entomologica Italiana, 86, 82-87.

Berio, E. 1959. Descrizione di tre specie nuove di Noctuidae provenienti dell' isola di Aldabra e de Nairobi (Kenya). Bollettino della Società Entomologica Italiana, 89, 11-12.

Berio, E. 1962. Diagnosi di alcune Noctuidae delle isole Seicelle e Aldabra. Ann. mus. civ. Genova, 73, 172-180.

Berlepsch, H. von. 1899. Vögel von der Insel Aldabra. Abhand. Senckenb. naturf. Gesellsch. 21, 489-496.

Bernhauer, M. 1922. Coleoptera, Staphylinidae. Trans. Linn. Soc. London, ser. 2, Zool. 18 (Percy Sladen Expedition Reports, 7), 165-186.

Blackman, R. A. A., editor. 1966. Bristol Seychelles Expedition 1964-65. Bristol: University of Bristol Expeditions Society, 1-32.

Boettger, O. 1913. Reptilien und Amphibien von Madagascar, den Inseln und dem Festland Ostafrikas. (Sammlung Voeltzkow 1889-1895 und 1903-1905). In A. Voeltzkow, Reise in Ostafrika in den Jahren 1903-1905, Wissensch. Ergebn. 3, 269-376.

Bolivar, I. 1912. Orthoptera: Acrydiidae, Phasgonuridae, Gryllidae. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 263-292.

Borradaile, L. A. 1910. On the land and amphibious Decapoda of Aldabra. Trans. Linn. Soc. London, ser. 2, Zool. 13 (Percey Sladen Expedition Reports, 2), 405-409.

Borradaile, L. A. 1917. On Carides from the western Indian Ocean. Trans. Linn. Soc. London, ser. 2, Zool. 17 (Percy Sladen Expedition Reports, 6), 397-412.

Boulenger, G. A. 1889. Catalogue of the Chelonians, Rhynchocephalians and Crocodiles in the British Museum. London.

Boulenger, G. A. 1909. A list of the freshwater fishes, batrachians, and reptiles obtained by Mr J. Stanley Gardiner's Expedition to the Indian Ocean. Trans. Linn. Soc. London, ser. 2, Zool. 12 (Percey Sladen Expedition Report, 1), 291-300.

Boulenger, G. A. 1911. List of the Batrachians and Reptiles obtained by Prof. Stanley Gardiner on his second expedition to the Seychelles and Aldabra. Trans. Linn. Soc. London, ser. 2, Zool. 14 (Percy Sladen Expedition Reports, 3), 375-378.

Boulton, F. R. P. 1960. Bird notes of a visit to islands in the Seychelles and adjacent groups north of Madagascar. Sea Swallow (Ann. Rept. Royal Naval Bird Watching Society), 13, 48-50.

Bourgogne, J. 1963. Sur deux Psychidae exotiques, dont une espèce inconnue des îles Aldabra-Cosmoledo. Bull. soc. entom. France, 68, 260-263.

Bourne, W. R. P. 1966. Observations on islands in the Indian Ocean. Sea Swallow (Ann. Rept. Royal Naval Bird Watching Society), 18, 40-43.

*Bowman, R. I., editor. 1966. The Galápagos. Proceedings of the Symposia of the Galápagos International Scientific Project. Berkeley and Los Angeles: University of California Press, i-xviii, 1-318.

*Broecker, W. S. and Thurber, D. L. 1965. Uranium-series dating of corals and oolites from Bahaman and Florida Key limestones. Science, 149, 58-60.

Budde-Lund, G. 1912. Terrestrial Isopoda, particularly considered in relation to the distribution of the southern Indo-Pacific species. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percey Sladen Expedition Reports, 4), 367-394.

(Budde-Lund, G. Onisciden von Madagaskar, etc., gesammelt von Dr A. Voeltzkow. Announced for publication in Abhand. Senckenb. naturf. Gesellsch. 27, by Voeltzkow 1902b, 563, who quotes 1 species from it; the paper did not appear.)

Burr, D. 1910. Dermaptera. Trans. Linn. Soc. London, ser. 2, Zool. 14 (Percy Sladen Expedition Reports, 3), 123-133.

Calvert, P. 1898. Odonata (dragonflies) from the Indian Ocean, and from Kashmir, collected by Dr W. L Abbott. Proc. Acad. Nat. Sci. Philadelphia, 1898, 141-154.

Campion, H. 1913. Odonata. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 435-446.

Carlquist, S. 1965. Island life: a natural history of the islands of the world. New York: Natural History Press. i-xii, 1-451.

*Carlquist, S. 1966. The biota of long-distance dispersal. I. Principles of dispersal and evolution. Quart. Rev. Biol. 41, 247-270.

Carpenter, G. H. 1916. The Apterygota of the Seychelles. Proc. Roy. Irish Acad. B, 33, 1-70.

Champion, G. C. 1914. Coleoptera, Curculionidae. Trans. Linn. Soc. London, ser. 2, Zool. 16 (Percy Sladen Expedition Reports, 5), 393-497.

Chapin, J. P. 1917. The classification of the weaver birds. Bull. Amer. Mus. Nat. Hist. 37, 243-280.

Christensen, C. 1912. On the ferns of the Seychelles and the Aldabra group. Trans. Linn. Soc. London, ser. 1, Botany, 7, 409-425; Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 407-422.

Cockerell, T. D. A. 1912. Hymenoptera, Apoidea. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 29-41.

Connolly, M. 1925. Notes on a collection of non-marine mollusca from the islands of the Indian Ocean. Journal of Conchology, 17, 257-266.

*Coppinger, R. W. 1883. Cruise of the "Alert". Four years in Patagonian, Polynesian, and Mascarene waters. (1878-82). London: W. Swan Sonnenschein and Co. i-xvi, 1-256.

*(Coppinger, R. W. and others.) 1884. Report on the Zoological collections made in the Indo-Pacific Ocean during the voyage of H.M.S. 'Alert' 1881-2. London: British Museum (Natural History). i-xxv, 1-684.

Cousteau, J.-Y. 1959. Aldabra, sanctuaire de corail. Paris: Éditions Ima. 1-91.

Cousteau, J.-Y. 1963. The living sea. London: Hamish Hamilton, 1-212. Chapter 9, Isles of Return, 97-108. (American edition, New York: Harper and Row, 1963, with different pagination).

Crook, J. H. 1961. The fodies (Ploceinae) of the Seychelles Islands. Ibis, 103a, 517-548.

*Darlington, P. J., Jr. 1957. Zoogeography: the geographical distribution of animals. New York: Wiley. i-xiv, 1-675.

*Darlington, P. J., Jr. 1965. Biogeography of the southern end of the world. Cambridge: Harvard University Press. i-xii, 1-236.

Davidson, W. E. 1911. (Letter dated 1 June 1910.) Proc. Zool. Soc. 1911, 622-624.

*Davies, D. and Francis, T. J. G. 1964. The crustal structure of the Seychelles Bank. Deep Sea Res. 11, 921-927.

*Degener, O., and Gillaspy, E. 1955. Canton Island, South Pacific. Atoll Research Bulletin 41, 1-51.

Delacour, J. 1943. A revision of the genera and species of the family Pycnonotidae (Bulbuls). Zoologica (New York), 28, 17-28.

Delacour, J. 1944. A revisision of the family Nectariniidae (Sunbirds). Zoologica (New York), 29, 17-38.

De Saussure, H. 1897. Orthoptera. Abhand. Senckenb. naturf. Gesellsch. 21, 569-664.

Distant, W. L. 1913. Rhynchota. Part I: Suborder Heteroptera. Trans. Linn. Soc. London, ser. 2, Zool. 16 (Percy Sladen Expedition Reports, 5), 139-191.

Distant, W. L. 1917. Rhynchota. Part II: Suborder Homoptera. Trans. Linn. Soc. London, ser. 2, Zool. 17 (Percey Sladen Expedition Reports, 6), 273-322.

Doederlein, L. 1902. Die Korallengattung Fungia. Abhand. Senckenb. naturf. Gesellsch. 27, 1-162.

Dupont, R. P. 1907. Report on a visit of investigation to St Pierre, Astove, Cosmoledo, Assumption and the Aldabra group. Victoria, Mahé: Government Printing Office. 1-51.

Dupont, R. P. 1916. Aldabra, its guano deposits and other resources. Unpublished report to the Seychelles Government.

Dupont, R. P. 1924. Essai sur la structure et la flore de quelques îles madréporiques de l'Océan Indien. Port Louis, Mauritius.

Dupont, R. P. 1929. The outlying islands of the Seychelles. Report to the Seychelles Government.

Eaton, A. E. 1913. Diptera, Psychodidae. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 423-432.

*Edmondson, C. H. 1923. Crustacea from Palmyra and Fanning Islands. Bishop Mus. Bull. 5, 1-43.

Edwards, F. W. 1912. Diptera, Tipulidae. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percey Sladen Expedition Reports, 4), 195-214.

Ehlers, E. 1897. Zur Kenntnis der ostafrikanischen Borstenwürmer. Nachrichten Königl. Gesellsch. Wissensch. zu Göttingen, Math.-phys. Kl., 1897, 158-176.

Eliot, C. N. E. 1910. Nudibranchs collected by Mr Stanley Gardiner from the Indian Ocean in H.M.S. 'Sealark'. Trans. Linn. Soc. London, ser. 2, Zool. 13 (Percy Sladen Expedition Reports, 2), 411-438.

*Elton, C. S. 1958. The ecology of invasions by animals and plants. London: Methuen. 1-181.

Enderlein, G. 1910. Embiidina and Neuroptera (Coniopterygidae und Hemerobiidae). Trans. Linn. Soc. London, ser. 2, Zool. 14 (Percy Sladen Expedition Reports, 3), 55-58.

Fairfield, E., Griffith, T. R., and Abbott, W. L. 1893. Aldabra Islands (correspondence). Bull. Misc. Inform. Roy. Gardens Kew, 1893, 152-155.

Fairmaire, L. 1896. Note sur quelques Coléoptères de l'île Aldabra. Bull. soc. entomol. France, 1896, 222-223.

Fauvel, A. 1909. Unpublished documents on the history of the Seychelles Islands before 1880. Mahé: Public Library.

Findlay, A. G. 1882. A directory for the navigation of the Indian Ocean, with descriptions of its coasts, islands, etc. London: R. H. Laurie, 4th edition. 1-1304.

*Fisher, H. I. 1966. Airplane-albatross collisions on Midway Atoll. Condor, 68, 229-242.

Fletcher, T. B. 1910a. Lepidoptera, exclusive of the Tortricidae and Tineidae, with some remarks on their distribution and means of dispersal amongst the islands of the Indian Ocean. Trans. Linn. Soc. London, ser. 2, Zool. 13 (Percy Sladen Expedition Reports, 2), 265-324.

Fletcher, T. B. 1910b. The Orneodidae and Pterophoridae of the Seychelles Expedition. Trans. Linn. Soc. London, ser. 2, Zool. 13 (Percy Sladen Expedition Reports, 2), 397-404.

Fleutiaux, E. 1923. Coleoptera: Melasidae et Elateridae des Séchelles et des îles voisines. Trans. entomol. Soc. London, 1922, 398-436.

Forel, A. 1897. Ameisen aus Nossi-Bé, Majunga, Juan de Nova (Madagaskar), den Aldabra-Inseln und Sansibar. Abhand. Senckenb. naturf. Gesellsch. 21, 185-208.

*Forel, A. 1907. Fourmis des Seychelles, Amirantes, Farquhar et Chagos. Trans. Linn. Soc. London, ser. 2, Zool. 12 (Percy Sladen Expedition Reports, 1), 91-94.

Forel, A. 1912. Fourmis des Seychelles et des Aldabras, reçues de M. Hugh Scott. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 159-167.

Fosberg, F. R. 1954. Aldabra, land of the giant tortoises. Unpublished paper, typescript, 1-10.

*Francis, T. J. G., Davies, D., and Hill, M. N. 1966. Crustal structure between Kenya and the Seychelles. Phil. Trans. Roy. Soc. A, 259, 240-261.

Friese, H. 1902. Hymenoptera von Madagaskar. Apidae, Fossores und Chrysididae. Abhand. Senckenb. naturf. Gesellsch. 26, 257-268.

Fryer, J. C. F. 1908-09. Journal. Manuscript. (Transcript by D. R. Stoddart).

Fryer, J. C. F. 1910. The South-west Indian Ocean (being an account of Aldabra and certain neighbouring islands, which were not explored by Prof. J. Stanley Gardiner in H.M.S. 'Sealark'). Geog. Journ. 37, 249-268; discussion 268-271.

Fryer, J. C. F. 1910. Aldabra and neighbouring islands. Proc. Cambridge Phil. Soc. 15, 340-346.

Fryer, J. C. F. 1911. The structure and formation of Aldabra and neighbouring islands--with notes on their flora and fauna. Trans. Linn. Soc. London, ser. 2, Zool. 14 (Percy Sladen Expedition Reports, 3), 397-442.

Fryer, J. C. F. 1912. The Lepidoptera of Seychelles and Aldabra, exclusive of the Orneadidae and Pterophoridae, and of the Tortricina and Tineina. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 1-28.

Gadow, H. and Gardiner, J. S. 1907. Aves, with some notes on the distribution of the land-birds of the Seychelles. Trans. Linn. Soc. London, ser. 2, Zool. 12 (Percy Sladen Expedition Reports, 1), 103-110.

*Gardiner, J. S., editor. 1903-06. The fauna and geography of the Maldive and Laccadive archipelagoes, being the account of the work carried on and of collections made by an expedition during the years 1899 and 1900. Cambridge: University Press, 2 volumes, i-ix, 1-471, 1903; i-viii, 473-1079, 1906.

Gardiner, J. S. 1906. The Indian Ocean, being results largely based on the work of the Percy Sladen Expedition in H.M.S. "Sealark", Comm. B. T. Somerville, 1905. Geog. Journ. 28, 313-332, 454-465; discussion, 465-471.

*Gardiner, J. S. 1907. Description of the expedition. Trans. Linn. Soc. London, ser. 2, Zool. 12 (Percy Sladen Expedition Reports, 1), 1-55, 111-175.

Gardiner, J. S. editor. 1907-36. Reports of the Percy Sladen Trust Expedition to the Indian Ocean in 1905. Trans. Linn. Soc. London, ser. 2, Zool., Volumes 12-19, 8 volumes.

Gardiner, J. S. 1931. Coral reefs and atolls: being a course of lectures delivered at the Lowell Institute at Boston, February 1930. London: Macmillan. i-xiv, 1-181.

Gardiner, J. S. 1936a. The reefs of the western Indian Ocean. I. Chagos Archipelago. II. The Mascarene Region. Trans. Linn. Soc. London, ser. 2, Zool. 19 (Percy Sladen Expedition Reports, 8), 393-436.

Gardiner, J. S. 1936b. Concluding remarks on the distribution of the land and marine fauna, with a list of the water temperature observations. Trans. Linn. Soc. London, ser. 2, Zool. 19 (Percy Sladen Expedition Reports, 8), 447-464.

Gaymer, R. D. T. 1966a. The land birds of the Seychelles Islands and the Aldabras, with a note on the giant tortoise of Aldabra atoll. Bristol Seychelles Expedition 1964-65: World Wildlife Fund Project No. 118. Typescript, 1-36.

Gaymer, R. D. T. 1966b. Aldabra--the case for conserving this coral atoll. Oryx, 8, 348-352.

Gaymer, R. D. T. 1966c. The green turtle Chelonia mydas japonica (Thunberg) in the Seychelles, Amirantes, and Aldabra group of islands. Mimeographed, 1-7.

Gaymer, R. D. T. 1967. Observations on the birds of Aldabra in 1964 and 1965. Atoll Research Bulletin 118.

Gaymer, R. D. T. and Penny, M. J. 1966. Wild life studies at Aldabra and in the Seychelles. J. Seychelles Soc. 5, 1-13.

Gebien, H. 1922. Coleoptera, Heteromera: Tenebrionidae. Trans. Linn. Soc. London, ser. 2, Zool. 18 (Percy Sladen Expedition Reports, 7), 261-324.

Gillies, M. T. and De Meillon, B. In press. Anophelinae of Africa south of the Sahara.

Green, E. E. 1907. Notes on the Coccidae collected by the Percy Sladen Trust Expedition to the Indian Ocean: supplemented by a collection received from Mr R. Dupont, Director of Agriculture, Seychelles. Trans. Linn. Soc. London, ser. 2, Zool. 12 (Percy Sladen Expedition Reports, 1), 197-207.

Greenway, J. C. 1958. Extinct and vanishing birds of the world. New York.

Grote, H. 1928. Neue Formen von Ostafrika, Aldabra und Madagaskar. Monatsber. Berlin, 36, 77-79.

Grouvelle, A. 1913. Coleoptera: Nitidulidae, Heteroceridae. Trans. Linn. Soc. London, ser. 2, Zool. 16 (Percy Sladen Expedition Reports, 5), 93-116.

*Guilcher, A. 1955. Géomorphologie de l'extremité septentrionale du Banc Farsan (Mer Rouge). Annales Inst. Océanograph. 30, 55-100.

*Guilcher, A., Berthois, L., Le Calvez, Y., Battistini, R., and Crosnier, A. 1965. Les récifs coralliens et le lagon de l'île Mayotte (archipel des Comores, Océan Indien): Géomorphologie, Sédimentologie, Hydrologie, Foraminifères. Paris: Orstom. i-vii, 1-210.

Guinot, D. 1964. Crustacés décapodes brachyoures (Xanthidae) des campagnes de la Calypso en Mer Rouge (1952), dans le Golfe Persique et à l'île Aldabra (1954). Mém. Mus. Nat. d'Hist. Natur., Sér. A, Zool. 32(1), 1-108.

*Gulick, A. 1932. Biological peculiarities of oceanic islands. Quart. Rev. Biol. 7, 405-427.

Günther, A. C. L. G. 1877. The gigantic land-tortoises (living and extinct) in the collection of the British Museum. London: Taylor and Francis. i-iv, 1-96.

Günther. A. C. L. G. 1879. On the occurrence of a land rail (Rallus) in the island of Aldabra. Ann. Mag. Nat. Hist. Ser. 5, 3, 164-168.

Hampson, G. F. 1908. On the moths collected during the cruise of the 'Valhalla' during the winter 1905-6 by Mr E. G. B. Meade-Waldo. Ann. Mag. Nat. Hist. Ser. 8, 1, 474-492.

*Hampson, G. F. 1920. Catalogue of the Lepidoptera Phalaenae in the British Museum. Supplement 2, 1-619.

Hartman, W. D. 1958. Report on some land birds of Farquhar, St Pierre, Astove, Cosmoledo, Assumption and Aldabra. Seychelles Government Bulletin. 27 January 1958.

Hartmann, R. 1886. Madagaskar und die Inseln Seychellen, Aldabra, Komoren und Maskarenen. Leipzig: G. Freytag. i-ii, 1-152.

Heck, L. 1957. Uber die Haltung von Riesenschildkroten (Testudo gigantea Dum. and Bibr.). Zeitschr. f. Aqua. u. Terrar. 10, 300-301.

Hemsley, W. B. 1916. Flora of Seychelles and Aldabra: new phanerogams, chiefly of the Percy Sladen Trust Expedition, with some emendations in synonymy. Journ. Bot. Brit. and For. 54, Supplement 2, 1-24, and continuation in Journ. Bot. Brit. and For. 54, 361-363.

Hemsley, W. B. 1917. Plants of Seychelles and Aldabra. Journ. Bot. Brit. and For. 55, 285-288.

Hemsley, W. B., and others. 1919. Flora of Aldabra: with notes on the flora of the neighbouring islands. Bull. Misc. Inform. Roy. Botanic Gardens Kew, 1919, 108-153.

*Hendrickson, J. R. 1966. The Galápagos tortoises, Geochelone Fitzinger 1835 (Testudo Linnaeus 1758 in part). In R. I. Bowman, editor. 1966. The Galápagos. Proceedings of the Symposia of the Galápagos International Scientific Project. Chapter 33, 252-257.

Herbulot, C. 1962. Nouveaux Geometridae d'Aldabra. Lambillionea, 62, 31-33.

Hermitte, L. C. D. 1931. Occurrence of Anopheles gambiae (costalis) in Aldabra Islands, Seychelles. Rec. Malaria Surv. India, 2(4), 643-654.

*Hesse, R., Allee, W. C., and Schmidt, K. P. 1951. Ecological animal geography. New York: Wiley. 2nd edition.

Hirst, S. 1913. Second report on the Arachnida--the Scorpions, Pedipalpi, and supplementary notes on the Opiliones and Pseudoscorpiones. Trans. Linn. Soc. London, ser. 2, Zool. 16 (Percy Sladen Expedition Reports, 5), 31-37.

*Holdgate, M. W. 1960. The ecology of islands. School Science Review, 41, 235-243.

*Holdgate, M. W. and Wace, N. M. 1961. The influence of man on the floras and faunas of southern islands. Polar Record, 10, 475-493.

Holland, W. J. 1895. List of the Lepidoptera from Aldabra, Seychelles and other East African Islands, collected by Dr W. L. Abbott. Proc. U.S. Nat. Mus. 18, 265-273.

Holmgren, N. F. 1910. Isoptera. Trans. Linn. Soc. London, ser. 2, Zool. 14 (Percy Sladen Expedition Reports, 3), 135-148.

Honegger, R. E. 1966a. Ornithologische Beobachtungen von den Seychellen. Natur und Museum, 96, 481-490.

Honegger, R. E. 1966b. Beobachtungen an der Herpetofauna der Seychellen. Salamandra, Zeitschr. f. Herpetologie und Terrarienkunde, 1-2, 20-36.

Honegger, R. E. In press. Beobachtungen an Riesenschildkröten Testudo gigantea auf den Seychellen. Salamandra, Zeitschr. f. Herpetologie und Terrarienkunde.

Honegger, R. E. In press. Some notes on the green turtle, Chelonia mydas japonica Thunberg in the Seychelle Islands. Zoologica (New York).

Hornell, James. 1927. The turtle fisheries of the Seychelles Islands. London(6): H.M.S.O. (?), 1-55.

Horsburgh, J. 1852, 1855. The India Directory, or, Directions for sailing to and from the East Indies, China, Australia, and the interjacent ports of Africa and South America: originally compiled from journals of the Honourable Company's Ships, and from observations and remarks, resulting from the experience of twentyone years in the navigation of these seas. London: W. H. Allen. 6th edition, 1852, 2 vols., 1-650, 1-890; 7th edition, 1855, 2 vols., 1-681, 1-978.

Hutchinson, G. E. 1950. Survey of existing knowledge of biogeochemistry. 3. The biogeochemistry of vertebrate excretion. Bull. Amer. Mus. Nat. Hist. 96, i-xviii, 1-554.

*Hutchinson, G. E. 1954. The dodo and the solitaire. Amer. Sci. 42, 300-305.

Jatzow, R. and Lenz, H. 1899. Fische von Ost-Afrika, Madagaskar und Aldabra. Abhand. Senckenb. naturf. Gesellsch. 21, 497-531.

*Jordan, K. 1939. On the constancy and variability of the differences between the Old World species of Utetheisa (Lepid.: Arctiidae). Novitat. Zool. 41, 251-291.

Julien, A. J. 1878. Gigantic land tortoises. Nature, 19, 30-31.

Karsch, F. 1900. Vorläufige kurze Kennzeichung von fünf neuen, durch Herrn Dr A. Voeltzkow in West-Madagaskar entdecken lepidopteren. Entomol. Nachrichten, 26, 369-370.

*Kaye, C. A. 1959. Shoreline features and Quaternary shoreline changes, Puerto Rico. U.S. Geol. Surv. Prof. Paper 317-B, 49-140.

Keller, Conrad. 1898. Ostafrikanischen Inseln. Berlin. 1-188.

Keller, Conrad. 1901. Madagascar, Mauritius and the other East-African Islands. London: Swan Sonnenschein. i-xiii, 1-242. Chapter XIX, The Aldabra Islands, 210-216.

Kerremans, C. 1914. Coleoptera, Buprestidae. Trans. Linn. Soc. London, ser. 2, Zool. 16 (Percy Sladen Expedition Reports, 5), 377-378.

Kertész, K. 1912. Diptera, Stratiomyiidae. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 95-99.

Kolbe, H. J. 1902. Koleopteren der Aldabra-Inseln. Abhand. Senckenb. naturf. Gesellsch. 26, 567-586.

Lamb, C. G. 1914. Diptera: Heteroneuridae, Ortalidae, Trypetidae, Sepsidae, Micropezidae, Drosophilidae, Geomyzidae, Milichidae. Trans. Linn. Soc. London, ser. 2, Zool. 16 (Percy Sladen Expedition Reports, 5), 307-372.

Lamb, C. G. 1922. Diptera: Asilidae, Scenopinidae, Dolichopodidae, Pipunculidae, Syrphidae. Trans. Linn. Soc. London, ser. 2, Zool. 18 (Percy Sladen Expedition Reports, 7), 362-416.

Lane, C. A. G. 1953a. The laws of Seychelles in force on the 30th June, 1952. Revised edition. London: Waterlow. 3 volumes, 1-2371 + 1-113.

Lane, C. A. G. 1953b. Subsidiary legislation of general application under the legislative enactments of Seychelles in force on the 30th day of June, 1952. London: Waterlow. 1-985 + 1-60.

Legrand, H. 1965. Lépidoptères des îles Seychelles et d'Aldabra. Mém. Mus. Nat. d'Hist. Natur., Sér. A, Zool. 37, 1-210.

Lenz, H. 1905. Ostafrikanischen Dekapoden und Stomatopoden. Abhand. Senckenb. naturf. Gesellsch. 27, 341-392. (This paper wrongly cited in Voeltzkow 1902b before publication as Lenz, H. Crustaceen von Ostafrika, Madagaskar und Aldabra, auf Grund der von Prof. Dr A. Voeltzkow in den Jahren 1889-1895 gemachten Sammlungen. Abhand. Senckenb. naturf. Gesellsch. 27.)

(Lenz, H. Arachniden von Madagaskar etc., gesammelt von Dr A. Voeltzkow. Announced for publication in Abhand. Senckenb. naturf. Gesellsch. 27 by Voeltzkow 1902b, 563, who quotes 2 species from it; the paper did not appear).

Linell, M. L. 1897. On the insects collected by Dr Abbott in the Seychelles, Aldabra, Gloriosa and Providence Islands, with descriptions of nine new species of Coleoptera. Proc. U.S. Nat. Mus. 19, 695-706.

*Lorenz, L. von. 1908. Die in historischer Zeit ausgestorben Vögel. Verhandl. zool. bot. Gesellsch. Wien, 58, 217-232.

Lorenz-Liburnau, L. von. 1899. Die Säugetiere von Madagaskar und Sansibar. Abhand. Senckenb. naturf. Gesellsch. 21, 441-469.

Loveridge, A. 1941. New Geckos (Phelsuma & Lygodactylus), snake (Leptotyphlops), and frog (Phrynobatrachus) from Pemba Island, East Africa. Proc. Biol. Soc. Wash 54: 175-178.

Loveridge, A. and Williams, E. E. 1954. Revision of the African tortoises and turtles of the suborder Cryptodira. Bull. Mus. Comp. Zool. 115, 161-557.

Ludwig, H. 1899. Echinodermen des Sansibargebietes. Abhand. Senckenb. naturf. Gesellsch. 21, 537-563.

*Macfadyen, W. A. 1930. The undercutting of coral reef limestone on the coasts of some islands in the Red Sea. Geog. Journ. 75, 27-34.

Mamet, R. 1943. A revised list of the Coccoidea of the islands of the western Indian Ocean, south of the equator. Mauritius Inst. Bull. 2 (1941-49), 137-170.

Matthai, G. 1914. A revision of the Recent colonial Astraeidae possessing distinct corallites (based on material from the Indo-Pacific Ocean and the collections of Paris, Berlin, Vienna, Copenhagen, London and Glasgow). Trans. Linn. Soc. London, ser. 2, Zool. 17 (Percy Sladen Expedition Reports, 6), 1-140.

Matthai, G. 1928. A monograph of the Recent meandroid Astraeidae. British Museum: Catalogue of Madreporarian Corals, 7, 1-288.

*Matthews, D. H. and Davies, D. 1966. Geophysical studies of the Seychelles Bank. Phil. Trans. Roy. Soc. A, 259, 227-239.

Mattinly, P. F. and Brown, E. S. 1955. Mosquitos of the Seychelles. Bull. entomol. res. 46, 69-110.

Maulik, S. 1931. Coleoptera, Chrysomelidae: Eumolpinae, Galerucinae and Halticinae. Trans. Linn. Soc. London, ser. 2, Zool. 19 (Percy Sladen Expedition Reports, 8), 241-260.

Mayr, E. and Vaurie, C. 1948. Evolution in the family Dicruridae (Drongos). Evolution, 2, 238-265.

Meade-Waldo, G. 1912. Hymenoptera, Diploptera. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 43-44.

Mees, G. F. 1957, 1961. A systematic review of the Indo-Australian Zosteropidae. Zool. Verhand. (Leiden), 35, 1-204; 50, 1-160.

Mertens, R. 1934. Die Insel-Reptilien, ihre Ausbreitung, Variation und Artbildung. Zoologica (Stuttgart), 84(2), 1-209.

Mertens, R. 1962. Stüdien uber die Reptilienfauna Madagaskars, III. Die Arten und Unterarten der Geckonengattung Phelsuma. Senckenbergiana biologica, Wissensch. Mitt. d. Senckenb. naturf. Gesellsch. 43, 81-127.

Meyrick, E. 1911. Tortricina and Tineina. Trans. Linn. Soc. London, ser. 2, Zool. 14 (Percy Sladen Expedition Reports, 3), 263-307.

Miller, G. S. 1902. Two new tropical old world bats. Proc. biol. soc. Washington, 15, 245-246.

Moreau, R. E. 1957. Variation in the western Zosteropidae (Aves). Bull. Brit. Mus. Nat. Hist. (Zool.), 4(7), 309-433.

Moreau, R. E. 1960a. The Ploceine weavers of the Indian Ocean islands. Journal für Ornithologie, 101, 29-49.

Moreau, R. E. 1960b. Conspectus and classification of the Ploceine weaver-birds. Ibis, 102, 298-321, 443-471.

Morris, R. O. 1964. The birds of some islands in the Indian Ocean. Sea Swallow (Ann. Rept. Royal Naval Bird Watching Society), 16, 68-79.

Needham, J. G. 1913. Neuroptera, Myrmeleonidae from the Indian Ocean. Trans. Linn. Soc. London, ser. 2, Zool. 16 (Percy Sladen Expedition Results, 5), 243-246.

Newman. K. B. (1965). An outline report on the present day status of birds and turtles in the Seychelles. Mimeographed, 1-12 (copy in Library, Fauna Preservation Society, London).

*Newnham, E. V. 1949. The climates of Addu Atoll, Agalega Islands and Tristan da Cunha. London: Meteorological Office, Prof. Notes, No. 101 (Vol. 7, i), 1-20.

Nicoll, M. J. 1906. On the birds collected and observed during the voyage of the 'Valhalla', R. Y. S., from November 1905 to May 1906. Ibis, Ser. 8, 6, 666-712.

Nicoll, M. J. 1908. Three voyages of a naturalist, being an account of many little-known islands in three oceans visited by the 'Valhalla' R.Y.S. London: Witherby. i-xxvi, 1-246. Chapter 12, Aldabra Island, 114-124.

Ommanney, F. D. 1952. The shoals of Capricorn. London: Longmans Green. i-viii, 1-322. Chapter 11, Aldabra, 258-294.

*Osmond, J. K., Carpenter, J. R., and Windom, H. L. 1965. Th^{230}/U^{234} age of the Pleistocene corals and oolites of Florida. Journ. Geophys. Res. 70, 1843-1847.

Palombelli, F. 1954. L'isola della Tartorughe. Epoca, 7 March 1954.

*Pantin, C. F. A., editor. 1960. A discussion on the biology of the southern cold temperate zone. Proc. Royal Soc. B, 152, 429-677.

Parsons, J. J. 1962. The green turtle and man. Gainesville: University of Florida Press. i-x, 1-126.

Penny, M. J. 1965. Bristol Seychelles Expedition, Part V. The birds of Aldabra. Animals, 7(15). 409-411.

Peters, A. J. 1957. Bibliography of published work bearing on the natural history of the Seychelles and neighbouring archipelagoes. Journ. Soc. Bibliog. Nat. Hist. 3, 238-262.

Piggott, C. J. 1961. Notes on some of the Seychelles Islands, Indian Ocean. Atoll Research Bulletin, 83, 1-10.

Pridham, C. 1846. England's colonial empire: historical, political and statistical account of the empire, its colonies and dependencies. Vol. 1. The Mauritius and its dependencies. London: Smith, Elder and Co. i-xii, 1-410.

Prosperi, F. 1955. Gran Comora. Roma: Ed. Garzanti. 1-284.

Prosperi, F. 1956. Au royaume des coraux. Trans. A. Schalit. Paris: Ed. Juillard.

Prosperi, F. 1957. Vanished continent: an Italian expedition to the Comoro Islands. Trans. D. Moore. London: Hutchinson. 1-232. Chapter 23, Aldabra, 190-195; Chapter 24, Giant Tortoises, 196-202.

*Rand, A. L. 1936. The distribution and habits of Madagascar birds. Bull. Amer. Mus. Nat. Hist. 72, 143-499.

Rathbun, M. J. 1894. Descriptions of two new species of crabs from the western Indian Ocean, presented to the National Museum by Dr W. L. Abbott. Proc. U.S. Nat. Mus. 17, 21-24.

Reclus, E. 1889. Nouvelle Géographie Universelle: La Terre et les hommes. XIV. Océan et terres océaniques. Paris: Hachette. 1-1004. Trans. by A. H. Keane, The Universal Geography. XIII. South and East Africa. London, no date. 1-504.

Régimbart, M. 1900. Coléoptères aquatiques capturés dans l'île d'Aldabra, près des Comores, par le Dr Voeltzkow, de Strasburg, et communiqués par le Dr Bergroth. Bull. Soc. entomol. France, 1900, 49-52.

Ridgway, R. 1893. Descriptions of some new birds collected on the islands of Aldabra and Assumption, northwest of Madagascar, by Dr W. L. Abbott. Proc. U.S. Nat. Mus. 16, 597-600.

Ridgway, R. 1894a. Note on Rougetius aldabranus. Auk, 11, 74.

Ridgway, R. 1894b. Descriptions of some new birds from Aldabra, Assumption, and Gloriosa Islands, collected by Dr W. L. Abbott. Proc. U.S. Nat. Mus. 17, 371-373.

Ridgway, R. 1895. On birds collected by Doctor W. L. Abbott on the Seychelles, Amirantes, Gloriosa, Assumption, Aldabra and adjacent islands, with notes on habits etc., by the collector. Proc. U.S. Nat. Mus. 18, 509-546.

Rothschild, W. 1915. On the gigantic land-tortoises of the Seychelles and Aldabra-Madagascar group, with some notes on certain forms of the Mascarene group. Novitates zool. 22, 418-442.

Rothschild, W. 1928. Notes on gigantic land tortoises. Proc. Zool. Soc. 1928, 658-660.

*Sachet, M.-H. and Fosberg, F. R. 1955. Island bibliographies: Micronesian botany; Land environment and ecology of coral atolls; Vegetation of tropical Pacific islands. Washington: National Academy of Sciences-National Research Council, Publication 335, i-vi, 1-577.

Schacht, P. 1902. Beiträge zur Kenntnis der auf den Seychellen lebenden Elefanten-Schildkröten. Wissensch. Ergebn. Deutsch. Tiefsee Exped. Valdivia 1898-1899, 3(3), 103-129.

Schenkling, S. 1922. Coleoptera: Cleridae. Trans. Linn. Soc. London, ser. 2, Zool. 18 (Percy Sladen Expedition Reports, 7), 325-329.

Schinz, H. 1897. Zur Kenntnis der Flora der Aldabra-Inseln. Abhand. Senckenb. naturf. Gesellsch. 21, 77-91.

Sclater, P. L. 1871. Description of a new species of dove from the coral-reef of Aldabra. Proc. zool. soc. 1871, 692-693, plate. Previously announced in: Additions to the menagerie (7 November 1871), Proc. zool. soc. 1871, 623.

Scott, H. 1912. Coleoptera, Lamellicornia and Adephaga. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 215-262.

Scott, H. 1913. Coleoptera: Hydrophilidae, Histeridae. Trans. Linn. Soc. London, ser. 2, Zool. 16 (Percy Sladen Expedition Reports, 5), 193-235.

Scott, H. 1914. Mallophaga, Aphaniptera, and Diptera Pupipara. Trans. Linn. Soc. London, ser. 2, Zool. 17 (Percy Sladen Expedition Reports, 6), 141-159.

Scott, H. 1922a. A geographical summary based on Dr Max Bernhauer's enumeration of the Staphylinidae of the Seychelles, Chagos, and Aldabra Islands, with notes on their biology. Trans. Linn. Soc. London, ser. 2, Zool. 18 (Percy Sladen Expedition Reports, 7), 187-193.

Scott, H. 1922b. Coleoptera: Scydmaenidae, Scaphidiidae, Phalacridae, Cucujidae (supplement), Lathridiidae, Mycetophagidae, (including Propalticus), Bostrychidae, Lyctidae. Trans. Linn. Soc. London, ser. 2, Zool. 18 (Percy Sladen Expedition Reports, 7), 195-260.

Scott, H. 1926. Coleoptera: Ciidae. Trans. Linn. Soc. London, ser. 2, Zool. 19 (Percy Sladen Expedition Reports, 8), 1-41.

Scott, H. 1936. General conclusions regarding the insect fauna of the Seychelles and adjacent islands. Trans. Linn. Soc. London, ser. 2, Zool. 19 (Percy Sladen Expedition Reports, 8), 307-391.

*Scott, R. 1961. Limuria: the lesser dependencies of Mauritius. London: Oxford University Press. i-xii, 1-308.

*Shor, G. G. and Pollard, D. D. 1963. Seismic investigations of Seychelles and Saya de Malha Banks, North-west Indian Ocean. Science, 142, 48-49.

Sicard, Dr. 1912. Coleoptera, Coccinellidae. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 361-366.

Siebenrock, F. 1904. Schildkröten von Madagaskar und Aldabra. Abhand. Senckenb. naturf. Gesellsch. 27, 239-260.

Smith, J. L. B. 1963. New species and new records of fishes from the western Indian Ocean. Ann. Mag. Hat. Hist. XIII, 6, 34-37.

Smith, J. L. B. and Smith, M. M. 1963. Fishes of the Seychelles. London, 1-215.

*Snow, D. W. 1964. The giant tortoises of the Galápagos Islands: their present status and future chances. Oryx, 7, 277-290.

Spurs, T. J. 1892. (Report on Aldabra to T. Risely Griffiths, Esq., Administrator of Seychelles Islands. Port Victoria, Seychelles, July 19, 1891.) Colonial Reports - Annual. No. 40. Mauritius (Seychelles and Rodriguez). Annual Reports for 1889 and 1890, with a report on the island of Aldabra. London: H.M.S.O. 1-50. Aldabra report, 46-50; letters of transmittal by T. R. Griffiths, 44-45.

Stein, P. 1910. Diptera, Anthomyidae, mit den Gattungen Rhinia und Idiella. Trans. Linn. Soc. London, ser. 2, Zool. 14 (Percy Sladen Expedition Reports, 3), 149-163.

Stejneger, L. 1893. On some collections of reptiles and batrachians from East Africa and the adjacent islands, recently received from Dr W. L. Abbott and Mr William Astor Chanler, with descriptions of new species. Proc. U.S. Nat. Mus. 16, 711-741.

*Stoddart, D. R., editor. 1966a. Reef studies at Addu Atoll, Maldive Islands: preliminary results of an expedition to Addu Atoll in 1964. Atoll Research Bulletin, 116, i-ii, 1-122.

Stoddart, D. R. 1966b. Report on the conservation of Aldabra, south-west Indian Ocean. Royal Society, mimeographed, 1-15.

Stoddart, D. R., editor. 1967a. Ecology of Aldabra Atoll, Indian Ocean. Atoll Research Bulletin 118.

Stoddart, D. R. 1967b. Scientific studies on Aldabra Atoll. Atoll Research Bulletin 118.

Stoddart, D. R. 1967c. Bibliography of Aldabra. Atoll Research Bulletin 118.

*Stoddart, D. R. In press. Reconnaissance geomorphology of Rangiroa Atoll, Tuamotu Archipelago. Atoll Research Bulletin.

Stoddart, D. R. and Wright, C. A. 1967a. Ecology of Aldabra Atoll. Nature, 213, 1174-1177.

Stoddart, D. R. and Wright, C. A. 1967b. Georgraphy and ecology of Aldabra Atoll. Atoll Research Bulletin 118.

Street, P. 1960. Can the giant tortoise survive? Discovery, 21, 158-160.

Theobald, F. V. 1912. Diptera, Culicidae. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 81-94.

Thiele, J. 1902. Verzeichnis der von Herrn Dr A. Voeltzkow gesammelten marinen und litoralen Mollusken. Abhand. Senckenb. naturf. Gesellsch. 26, 241-252.

Travis, W. 1959. Beyond the reefs. New York: Dutton. 1-221. On Aldabra, Chapters 8 and 9, 157-193.

True, F. W. 1893. Description of a new species of fruit bat, Pteropus aldabrensis, from Aldabra Island. Proc. U.S. Nat. Mus. 16, 533-534.

Turner, R. E. 1911. Fossorial Hymenoptera from the Seychelles and other islands in the Indian Ocean. Trans. Linn. Soc. London, ser. 2, Zool. 14 (Percy Sladen Expedition Reports, 3), 367-374.

Vaurie, C. 1949. A revision of the family Dicuridae. Bull. Amer. Mus. Nat. Hist. 93, 199-342.

*Veeh, H. H. 1965. Thorium-230/Uranium-238 and Uranium-234/Uranium-238 ages of elevated Pleistocene coral reefs and their geological implications. University of California at San Diego, Ph.D. thesis. i-xii, 1-91.

*Veeh, H. H. 1966. Th^{230}/U^{238} and U^{234}/U^{238} ages of Pleistocene high sea level stand. Journ. Geophys. Res. 71, 3379-3386.

Veevers-Carter, R. M. 1962. The development of the green turtle (Chelonia mydas) fisheries of the Seychelles. Mahé: Department of Agriculture, report.

Vesey-FitzGerald, D. 1940. The birds of the Seychelles. 1. The endemic birds. Ibis, ser. 14, 4, 480-489. Appendix--Birds of the Aldabra Group, 486-489.

Vesey-FitzGerald, D. 1941. Further contributions to the ornithology of the Seychelles Islands. Ibis, ser. 14, 5, 518-521.

Vesey-FitzGerald, D. 1942. Further studies of the vegetation on islands in the Indian Ocean. J. Ecol. 30, 1-16.

*Vesey-FitzGerald, D. 1950. Nesting habits of some aculeate Hymenoptera in the Seychelles. Proc. entomol. soc. London, A, 25, 75-80.

*Vesey-FitzGerald, D. and Parker, H. W. 1947. Reptiles and amphibians from the Seychelles archipelago. Ann. Mag. Nat. Hist. Ser. 11, 14, 577-584.

Viette, P. 1958. Note sur des petites collections de Lépidoptères récoltés aux îles Comores et en Aldabra. Lambillionea, 58, 60-65.

Voeltzkow, A. 1896. Riesenschildkröten von Aldabra. Zool. Garten, 37, 30.

Voeltzkow, A. 1897. Einleitung: Madagaskar, Juan de Nova, Aldabra. Abhand. Senckenb. naturf. Gesellsch. 21, 1-76. Aldabra, Indischer Ocean 1895, 40-73 (mimeographed translation available).

Voeltzkow, A. 1897-99. Wissenschaftliche Ergebnisse der Reisen in Madagaskar und Ostafrika in den Jahren 1889-95. Band I. Abhand. Senckenb. naturf. Gesellsch. 21, 1-664.

Voeltzkow, A. 1902a. Über Coccolithen und Rhabdolithen nebst Bemerkungen über den Aufbau und die Entstehung der Aldabra-Inseln. Abhand. Senckenb. naturf. Gesellsch. 26, 461-537.

Voeltzkow, A. 1902b. Die von Aldabra bis jetzt bekannte Flora und Fauna. Abhand. Senckenb. naturf. Gesellsch. 26, 539-565.

Voeltzkow, A. 1913. Reise in Ostafrika in den Jahren 1903-1905. Wissenschaftliche Ergebnisse. Band III Stuttgart.

Von Martens, E. and Wiegmann, F. 1898. Land- und Süsswasser-Mollusken der Seychellen nach den Sammlungen von Dr. Aug. Brauer. Mitteilungen aus der Zoologischen Sammlung des Museums für Naturkunde in Berlin, 1, 1-94 (I. Conchyliologischer Theil, by E. von Martens, 3-35).

Wace, N. M. 1965. Future of the Tristan da Cunha Islands. Nature, 207, 1232-1234.

*Warburton, C. 1912. The Acarina of the Seychelles. Trans. Linn. Soc. London, ser. 2, Zool. 15 (Percy Sladen Expedition Reports, 4), 349-360.

Wasmann, E. 1897. Termiten von Madagaskar und Ost-Afrika. Abhand. Senckenb. naturf. Gesellsch. 21, 137-182.

Watson, G. E., Zusi, R. L., and Storer, R. E. 1963. Preliminary field guide to the birds of the Indian Ocean. Washington: Smithsonian Institution. i-x, 1-214.

Weber-Van Bosse, A. 1914. Marine algae, Rhodophyceae. Trans. Linn. Soc. London, ser. 2, Zool. 16 (Percy Sladen Expedition Reports, 5), 269-306.

Wermuth, H. and Mertens, R. 1961. Schildkröten, Krokodile, Brückenechsen. Jena: VEB Gustav Fischer Verlag. i-xxvi, 1-422.

Wharton, W. L. 1879. (Letter on Aldabra, from H.M.S. Fawn, off Zanzibar, 16 August 1878, included in the paper by Günther 1879.) Ann. Mag. Nat. Hist. Ser. 5, 3, 165-166.

Wharton, W. J. L. 1883. Mangrove as a destructive agent. Nature, 29, 76-77.

Wheeler, J. F. G., and Ommanney, F. D. 1953. Report on the Mauritius-Seychelles Fisheries Survey 1948-1949. Colonial Fisheries Research Publications, 1(3), 1-145.

Wheeler, J. F. G. 1953a. Extracts from the scientific data of the 11th cruise of M.F.R.V. I, leading to a tentative evaluation of the fish potential of the Aldabra Islands (May 20 1948). Appendix 4, pp. 139-143, in Wheeler and Ommanney 1953.

Wheeler, J. F. G. 1953b. Memorandum on the green turtle (May 12 1948). Appendix 5, pp. 143-145, in Wheeler and Ommanney 1953.

Williams, E. 1952. A new fossil tortoise from Mona Island, West Indies, and a tentative arrangement of the tortoises of the world. Bull. Amer. Mus. Nat. Hist. 99, 541-560.

*Wiseman, J. D. H. 1936. The petrography and significance of a rock dredged from a depth of 744 fathoms, near to Providence Reef, Indian Ocean. Trans. Linn. Soc. London, ser. 2, Zool. 19 (Percy Sladen Expedition Reports, 8), 437-443.

Yvon, F. Durocher. No date. Report to the Seychelles Government on Aldabra, Astove, Assumption and Cosmoledo Atolls. Unpublished report to the Seychelles Government.

1. Exposed coastal cliffs, Point Hodoul. Note the extreme dissection of the champignon, and the intertidal algal platform.

2. Medium-energy coastal cliffs, east of East Channel, mid-tide.

3. Boulder zone on reef-flat at low tide, Anse Cèdres.

4. Small pocket beach on medium-energy coast, near Anse Cèdres, low tide. Note the perched beach above the cliff line.

5. Pocket beach at Anse Cèdres, mid-tide; beachrock in the foreground.

6. Low coastal dunes, seaward coast near Takamaka.

7. Moderate coastal dunes, seaward coast near Cinq Cases.

8. Moderate coastal dunes with coarse grasses between Takamaka and Cinq Cases.

9. Dunes at the south end of West Island; intertidal flat in the foreground exposed at low water.

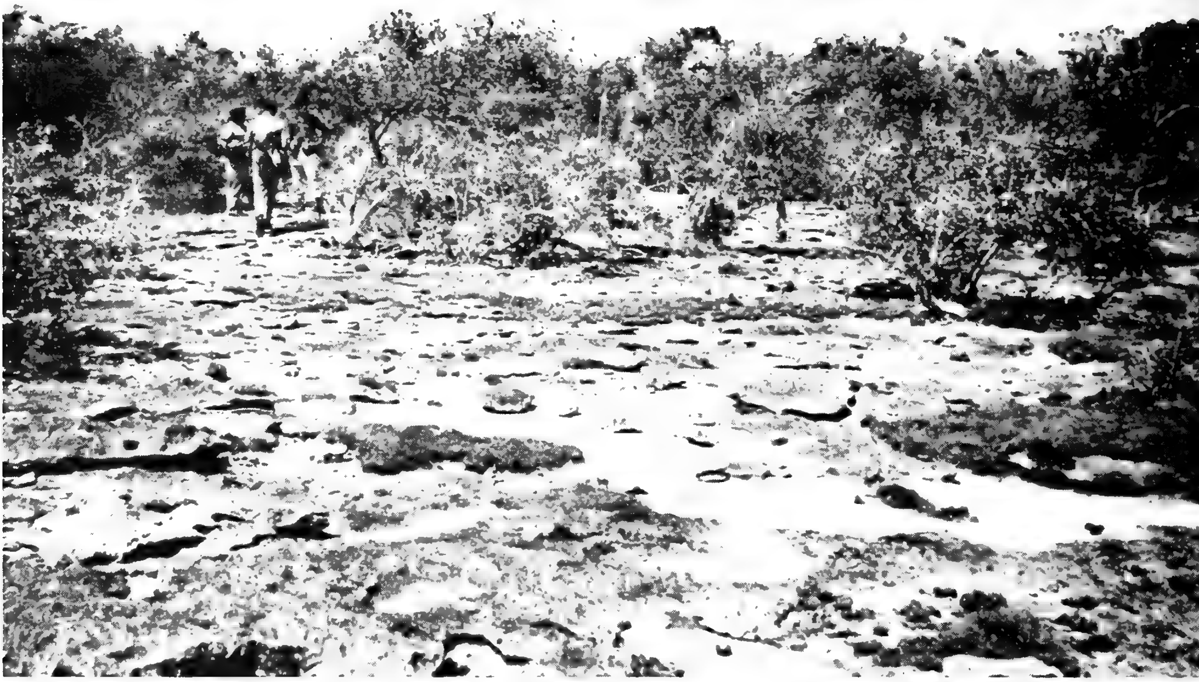
10. Undercut lagoon cliffs, South Island near East Channel.

11. Undercut lagoon islets, low tide, South Island near East Channel. The amplitude of the notch is about 6 ft.

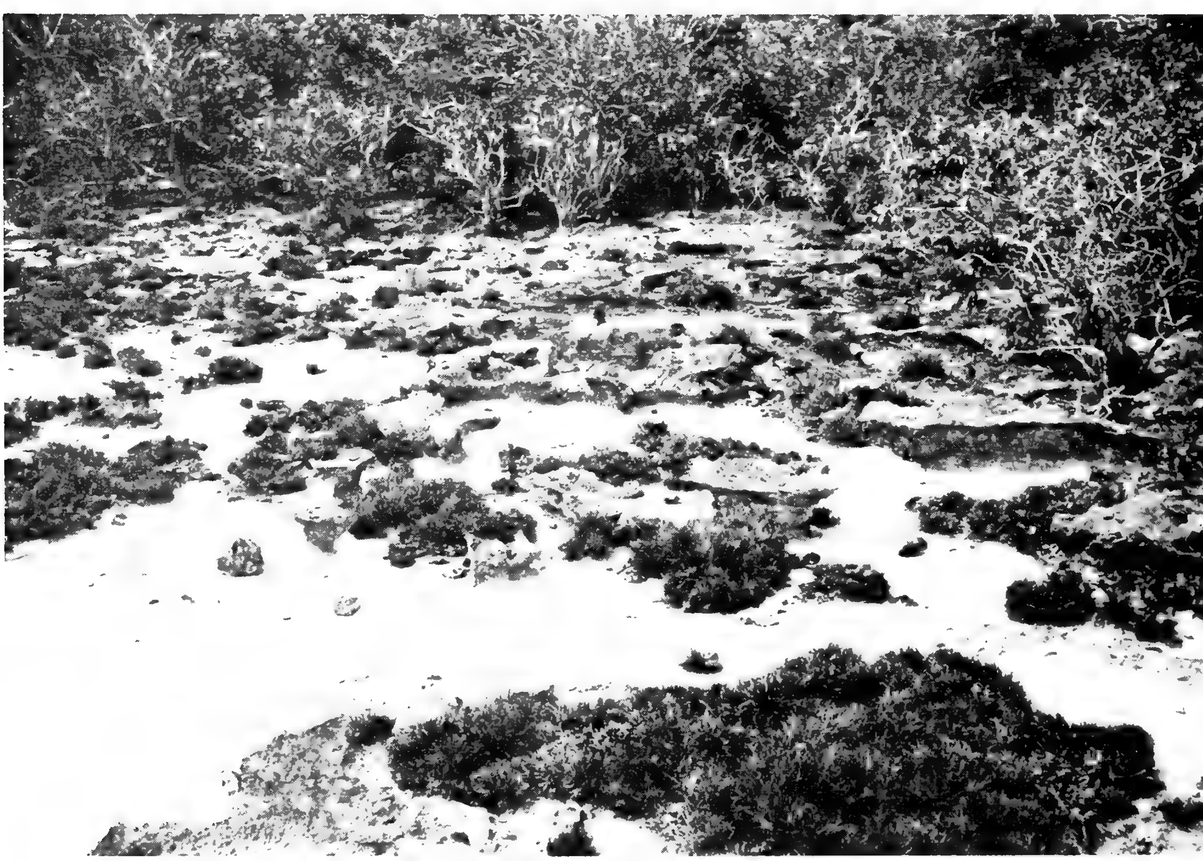
12. Sand-spit at the south end of West Island, colonised by Cyperus maritimus and seedlings of Scaevola and Tournefortia.

13. Pot-holed surface of champignon, South Island close to East Channel. Soil is found only on the floors of the potholes and not on the ground surface.

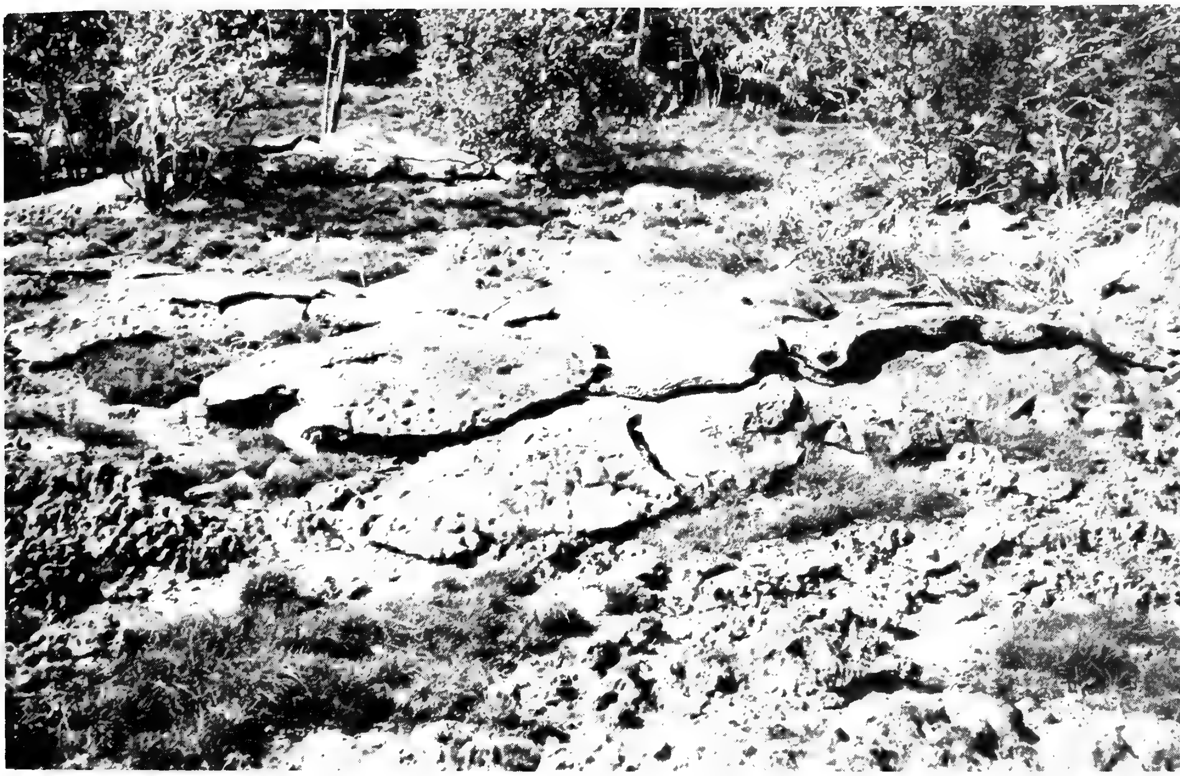
14. Karst landforms in shelly limestone on Ile Esprit. The vertical amplitude of the pinnacles from the flat enclosed floors to the summit ridges is 18 ft.



15. Platin with Mixed Scrub, three miles southeast of East Channel, on South Island.



16. Incised pools and residuals on the platin surface, South Island, near Frigate Pool. The ground vegetation is Fimbristylis spathacea.



17. Surface exfoliation on platin near Frigate Pool, South Island. Some of the limestone sheets are completely detached. At the left of the photograph is a small area of mammillate limestone formed by secondary deposition.

18. Flat platin under open Mixed Scrub, showing residuals of brown limestone 3-4 ft. high, near Flamingo Pool, South Island.

19. Brown-limestone residual 6 ft high, near Flamingo Pool, South Island. The surface of the residual is furrowed by solution.

20. Seaward fringe of the Mixed Scrub community south of Takamaka. The vegetation is sparse and almost all the shrubs and trees are dead, except for Pandanus.

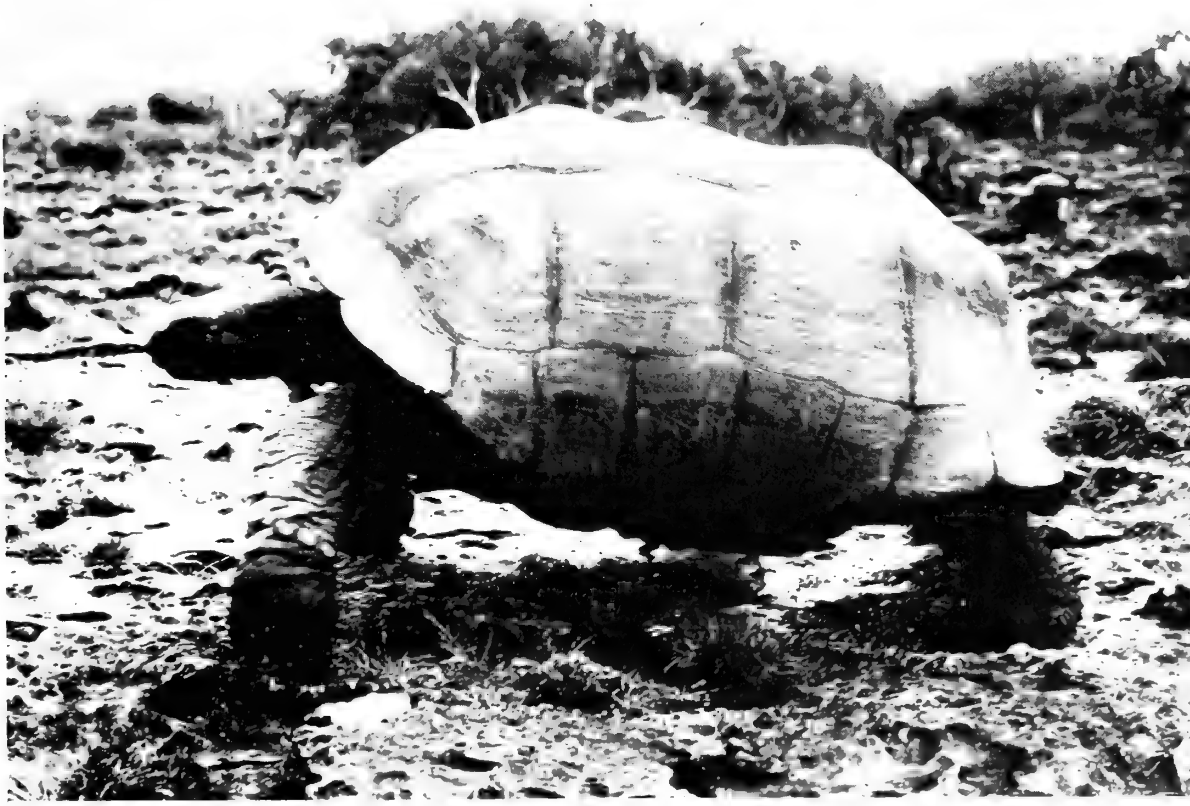
21. Large tidal solution hole in champignon near Point Hodoul, South Island, being flooded by the rising tide. Note the basal solution notching on the islands.

22. Takamaka pool, showing the large Ficus in which Pteropus aldabrensis is found.

23. Fresh water in a semi-permanent water course at Cinq Cases, South Island, surrounded by dense Acrostichum aureum and Pandanus.

24. Freshwater pool used as a tortoise wallow, surrounded by Pandanus, on South Island, three miles southeast of East Channel.

25. Tortoises wallowing in a freshwater pool during the morning: one in the centre of the pool is dead.



26. Giant land tortoise, Testudo gigantea (Photo: R. Gaymer).

27. Tortoise on the dry floor of a freshwater pool, during the dry season, near Takamaka, South Island.

28. Tortoise and a Sacred Ibis, Threskiornis aethiopicus abbotti, near Frigate Pool, South Island.

29. Frigate-birds diving for water at Frigate Pool, South Island.

30. Juvenile Red-footed booby, Sula sula rubripes on Polymnie (Photo: R. Gaymer).

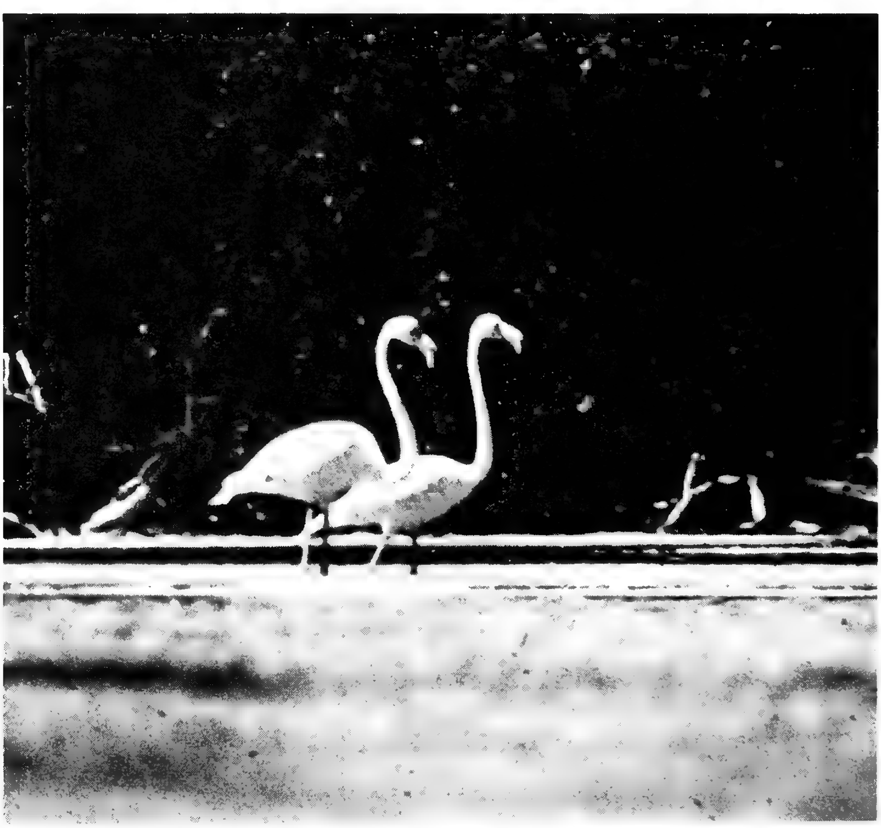
31. Red-tailed Tropic Bird, Phaëthon rubricauda rubricauda, on a lagoon islet inside East Channel.

32. Adult Sacred Ibis, Threskiornis aethiopicus abbotti (Photo: R. Gaymer).

33. Colony of Sacred Ibis at Takamaka, South Island (Photo: R. Gaymer).

34. Flightless Rail, Dryolimnas cuvieri aldabranus (Photo: R. Gaymer).

35. Male Red-Headed Forest Fody, Foudia eminentissima aldabrana, giving threat display in his territory. Note the drooped wings and tail, and raised head and rump feathers (Photo: R. Gaymer).



36. Pair of Flamingos, Phoenicopterus ruber roseus, wading in a brackish pool in mangrove on South Island (Photo: R. Gaymer).

37. Casuarina woodland at Anse Cèdres, South Island.

38. Coconut plantation, south end of West Island.

39. Settlement on West Island.

40. One of the rainwater tanks in the West Island settlement.

41. Fishing shack on Middle Island, at East Channel.

ATOLL RESEARCH BULLETIN

No. 119

Atoll News and Comment

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D.C., U.S.A.

November 15, 1967

ATOLL NEWS AND COMMENT

This feature of the ARB will be continued under the new auspices (see below) along the same lines as in the earlier issues. It will be included as material is available. Hence news, original research notes, bibliographic notices and reviews pertaining to atolls, reefs, and related island subjects will be welcome and will be included if they seem appropriate.

NEWS

In this section we will continue to give news items of possible interest to ARB readers. We will appreciate being informed of activities of our colleagues, expeditions, investigations, meetings, and other events pertaining in any way to coral islands or reefs.

ARB Resumes Publication

We are glad to be able to announce that we are back in business, now under Smithsonian Institution auspices. We enjoyed our 15 years of association with the Pacific Science Board and very much appreciate the support provided for the Coral Atoll Program including ARB by the Office of Naval Research. Because of the interest of the Ecology, Oceanography, and Systematics programs of the Smithsonian we have at least our next year's support arranged. The Bulletin will continue to be distributed gratis to those individuals who are actively engaged in research in some way related to reefs and islands, to administrative agencies with responsibilities related to islands, to appropriate educational institutions, and to libraries whose collections are available for use of the scientific public. Requests to be placed on the mailing list should be accompanied by information showing that the requestor fits into one of the above categories. Otherwise they cannot be considered.

To provide greater flexibility in selecting papers offered, the scope of the Bulletin is being broadened somewhat. Papers may be accepted that deal with other types of tropical islands, either elevated coral islands or partially or wholly volcanic islands if they relate in some way to coral atoll or reef ecology. It should be clearly understood that papers on low islands and atolls will have priority over those on high or volcanic islands.

The editors would appreciate in exchange publications in the general fields of island biology and geology, marine ecology and geology, and on the tropics generally. Such publications may be noted or even reviewed in the ARB when appropriate.

The editing and distribution of the ARB is being resumed as a part of the Smithsonian's Program in Tropical Biology, which, it is hoped, may continue to stress coral atoll ecology.

We wish to express our appreciation for the concern voiced in the many letters from readers that followed our announcement that we had suspended publication, also for the many offers to subscribe if ARB could be continued

on a subscription basis. We are happy to be able to continue, at least for the present, to send it gratis.

Gilbert Islands - SPC Health Conference in Tarawa

The South Pacific Commission is holding a seminar on Health Problems of Coral Atoll Populations at Tarawa, Gilbert Islands, May 1-11, 1967. Representatives from a number of jurisdictions in the Pacific have been invited, as well as a number of consultants, including the editor of ARB. It is gratifying that the SPC health authorities regard ecology as of sufficient concern to have included an ecologist in their list of consultants.

British Indian Ocean Territory

By an order (S. I. No. 85 of 1965) signed by the Queen dated 8 November 1965, the British Government created The British Indian Ocean Territory, a new political entity. The territory includes the Chagos Archipelago, the Farquhar Islands, the Aldabra group, and Desroches Island. These islands, formerly under the jurisdiction of Mauritius and the Seychelles, will henceforth be administered for the Crown by a Commissioner appointed by the Queen.

The purpose of this action, it is rumored, is to make possible the use of the islands for military or other establishments without any likelihood of objection by political entities (Mauritius and the Seychelles) which may at some time become independent. The islands comprising the new Territory are so sparsely populated that no such problems are anticipated. For the present the laws and enactments in force under the previous jurisdictions will remain in force until modified by orders issued by the Commissioner.

Chagos Archipelago:--Diego Garcia Expedition

According to The Times (London), May 1, 1967, "A Royal Navy survey ship carrying a joint team of U.S. Navy and British Defence Ministry experts is sailing this summer to investigate the possibilities, for defence purposes, of a small chain of "islands" in the sun.

"H.M.S. Vidal will set off in about six weeks to Diego Garcia, a part of the Chagos Archipelago, in British Indian Ocean territory. . ."

Several British and U.S. scientists will be included in the group. We have only rumors as to who they will be, but at least our correspondent, David Stoddart, of Cambridge University, seems certain to go. We hope to have an account of the results for our readers after they return. After the Diego Garcia visit is finished, at least some of the scientists will go on the Vidal to Aldabra on the first part of the Royal Society Expedition to Aldabra. This expedition will have two parts, one in the dry season this summer, the other in the wet season next February. This is a follow-up of the British Broadcasting Company Royal Society Expedition to Aldabra last summer, reported in ARB 118, in this issue.

Caroline Islands

Vern Carroll is returning to Nukuoro in May to continue his anthropological studies there. We have a good series of herbarium specimens from him, representing the plant species that the local people consider "pre-contact," that is, existing on the island before it was first visited by Europeans. He hopes to be able to get the "post-contact" species on this trip.

Mr. Edward R. Murray, a Peace Corps volunteer, has been for the past few months on Kapingamarangi. He has set up a weather station and is recording daily observations. He has also taken a complete census of the population, and is making other observations of ecological interest.

ORIGINAL OBSERVATIONS

It will be the policy of the editors to include in this section any short notes or papers that total not more than three pages of text. The authors' names will, of course, be given. This is the interests of economy, as to make separate numbers of such papers involves considerable extra work and some expense.

The Identity of the Rats on Heron Island, Capricorn Group, Queensland, Australia

F. I. Norman, Department of Zoology and Comparative Physiology, Monash University, Clayton, Victoria.

Moulton (1961), when discussing the fauna of the island, mentioned that old "reef heron nests are at times filled with partially gnawed Pandanus fruits, probably by the island rat Rattus exulans". Troughton (1962) mentions the species only in regard to its similarity with a specimen from the Albrolhos, which Tate (1951) considered strongly resembling R. exulans. Troughton, however, thought that it should be provisionally accepted as a species, R. glauerti. Tat (1951) gives examples of only two occurrences of R. exulans within Australia: a male from Adele Island, northern Western Australia and an adult from Lagrange Bay and notes that a subspecies also occurs at the Aru Island Group, Ceram and Amboina. Thus it was doubted that the species at Heron Island was, in fact, R. exulans.

In May 1965, during a ten days' stay on the island it was noticed that the eggs of the green turtle, Chelonia mydas, were hatching and the young moving downwards, at night, to the sea. On two occasions small groups of two and three young were found dead with the soft parts of the neck ripped open. Damaged individuals were also noticed, the majority with bleeding flippers, and rats were seen in the immediate neighborhood. Six rats later caught were identified as R. rattus, an opinion later confirmed by B.J. Marlow of the Australian Museum, Sydney (in litt.). No other species of rat was caught, or seen, and it is thought that the 'island rat' is, in fact, Rattus rattus.

References

Moulton, J. M. (1961). Some observations on the Heron Island fauna. Atoll Research Bulletin, 82:15-16.

Tate, G. H. H. (1951). The rodents of Australia and New Guinea. Bull. Am. Mus. Nat. Hist. 97:187-430.

Troughton, E. le G. (1962). Furred animals of Australia. Angus and Robertson, Sydney. 7th Ed.

PUBLICATIONS

We intend to continue to publish announcements or brief reviews of books and other publications with a bearing on atolls and reefs, and on islands in general if there seems to be some relation to the ecology of coral atolls. As can be seen from the notices below, we interpret this very broadly. How many such publications are noted and the thoroughness with which they are reviewed will depend very much on what is brought to the attention of the editors and how much time the editors can take to read and review them. Reviews by others, if not too lengthy, will be accepted and published at the editors' discretion.

Brown, W. L., Jr. (ed). - Pilot register of zoology. Cards 1-20. Cornell University, Ithaca, New York. 1964. This is a new departure in publication of taxonomic information. Admittedly an experiment, it is an attempt to put the original descriptions and illustrations, as well as new combinations, reductions to synonymy and, probably, critical discussions, on large cards with perforated edges for key-sorting. The cards are substantial, well printed, perforated for binding in three-hole ring binders. To explain the plan, the following three paragraphs are reproduced from the information sheet sent out with the trial set of cards.

> "The series of twenty cards enclosed for your departmental library represents a new experiment in publication in the field of systematic zoology, the Pilot Register of Zoology, sent you with the compliments of the Department of Entomology and Limnology, New York State College of Agriculture at Cornell University. The cards are intended to demonstrate the advantages of publishing basic taxonomic information by employing species and genera as modular units that can be used to build a register file (card catalog). Possibilities for improved retrieval of information are embodied in the keysort margin of the card. The top edge, for instance, is designed to take punching for a card serial number of up to nine digits. The right, left and bottom margins are free for punching according to any system of coding the user cares to develop, including those based on morphology, taxonomic affiliation, behavior, ecology, geographical distribution, or others.
>
> "The entries published on these cards are validly published under the International Code of Zoological Nomenclature, and the new species described are intended to be available for purposes of homonymy and synonymy; they have not been published elsewhere. The Register is distributed to over 1,000 institutions and individuals in all parts of the earth. Additional sets of this issue are available for the cost of mailing, $0.25 USA, upon application to: REGISTER, DEPARTMENT OF ENTOMOLOGY, CORNELL UNIVERSITY, ITHACA, NEW YORK, USA.

"It is hoped that the Pilot Register of Zoology will point the way toward the eventual adoption and sponsorship by some international agency of a continuing series of register cards more or less like these, that will contain not only all new taxonomic proposals, but will also be extended back in time to catalog in modular form all the taxa with their descriptions, figures and other data from Linnaeus onward. Some cards in the present series illustrate the possibilities in this direction. However, there are no present plans to issue further sets of the Pilot Register of Zoology after this one."

Our impression is that if this system had been used from the beginning of valid zoological publication it would have been excellent. Now, after between one and two million names of animal species (including synonyms) have been published in conventional media, the economics of transferring all of these to cards, especially since a whole card is used per species, whether the description is two pages or two lines long, are to say the least, doubtful. We also have doubts that the publication habits of the thousands of practicing systematic zoologists can be changed so readily as to make this system a success in less than a few generations. The suggestion that "some international agency" might adopt and continue this series leaves us rather skeptical, after some experience with existing international organizations and their financial and organizational problems. No international organization that we are familiar with has the continuity of purpose, combined with assurance of the necessary level of financial support to justify undertaking a continuing project of anything like this magnitude.

We wish this project well but have little optimism.

Whitehill, Joseph. Precious Little. 1-221, Scribner, New York, 1967, $4.50. - It may not seem appropriate to review a novel in the ARB, and certainly we do not intend to make a practice of it. However, this is a very special novel. It is about an imaginary geophysical expedition to an imaginary island in the mid-Pacific, sent out by an imaginary institute of oceanography. It was a well-conceived and well-planned, if under-financed, expedition, which started out with every chance of success. A mounting series of administrative blunders, against which the men in the field were helpless, led first to frustration and inefficiency, then to disaster and the failure of the expedition.

Those who have never been in the field, depending on home base for support, may find some of what happened hard to believe. Some who have been on such expeditions will feel right at home. The characters are well-drawn, slightly exaggerated, perhaps, but convincing. The island is not too bad for an imaginary place. The account of the expedition shows that the author did his homework, even if he has never been on such a trip.

This book can be recommended to those who have been on expeditions for the feelings it will evoke, to those who expect to go on an expedition as preparation, and to the stay-at-homes as entertainment. It should be required reading for all administrators who ever possibly may have to do with sending a party on a long expedition.

Silvester, R., Coral Reefs, Atolls and Guyots. Nature 207:681-688, 1965. This paper, kindly sent by the author, presents an entirely new, and entirely unique, theory of the origin of atolls. We do not feel able to

comment on this and can only suggest that the curious look it up and appraise it for themselves.

Barrau, J. An ethnobotanical guide for anthropological research in Malayo-Oceania (preliminary draft). 1-149, [Bangkok 1966]. For years the science of ethnobotany has existed in an indefinite fashion with a horde of amateurs and a few competent professionals as its practitioners. It was even difficult to find an adequate description of the field. Yet it is a field that fascinates practically everyone who does any botanical work in an area where relatively primitive people still live, and that makes a very significant contribution to many ethnological studies.

Barrau, at the request of the Unesco Southeast Asia Science Cooperation Office, as a part of its contribution to the Unesco Humid Tropics Programme, has produced a work that effectively dispels the vagueness that surrounds ethnobotany and presents a comprehensive and adequate definition and circumscription of the field. The guide is a mimeographed document, distributed at the 11th Pacific Science Congress, with a request for suggestions. It is, as stated, a preliminary draft, in extremely rough form leaving about everything to be desired editorially. Its specific subject matter and bibliography concern "Malayo-Oceania," Indo-China, Malesia and the insular Pacific, but its treatment of Ethnobotany serves equally well any region of the world where primitive man or even his archeological remains still exist.

Both the philosophy and the techniques of the science are effectively described and exemplified by investigations on plants and peoples of the western Pacific, where the author is the outstanding authority. An annotated list of the vascular plants of ethnobotanic importance in the region is of much interest. The breadth of his concept is shown by his stressing the taxonomy of the plants as well as their relation to man, the history and geography of man and his plant associates, and the relationships of man to vegetation. Proper methods of collection and preservation of material are explained, the pitfalls of uncritical recording of information supplied by informants, and the need for looking at the ethnobotanical aspects of a culture from within the cultural and linguistic framework, are stressed.

We hope that the response in the form of suggestions and comments is so enthusiastic that the author will get on at once with the preparation of an edited and generally available version. Even after this rough draft, ethnobotany will never again be the same. We will spare our readers our specific comments, but will make them directly to our friend Jacques Barrau. Here we will merely congratulate him on his complete mastery of his field.

GPO 927-778

Nos. 120 through 126

March 30, 1969

ATOLL RESEARCH BULLETIN

Issued by
THE SMITHSONIAN INSTITUTION
Washington, D.C., U.S.A.

ATOLL RESEARCH BULLETIN

Issued by
THE SMITHSONIAN INSTITUTION
Washington, D.C., U.S.A.

March 30, 1969

ACKNOWLEDGEMENT

The Atoll Research Bulletin is issued by the Smithsonian Institution as a part of its Tropical Biology Program. It is supported cooperatively by the Oceanography, Ecology, and Systematics Programs and by the Smithsonian Press. The Press handles production and distribution. The editing is done by the Tropical Biology staff in the Museum of Natural History.

The Bulletin was founded and the first 117 numbers issued by the Pacific Science Board, National Academy of Sciences, with financial support from the Office of Naval Research. Its pages were largely devoted to reports resulting from the Pacific Science Board's Coral Atoll Program.

ATOLL RESEARCH BULLETIN

No. 120

A RECORD OF BENTHIC MARINE ALGAE FROM JOHNSTON ATOLL

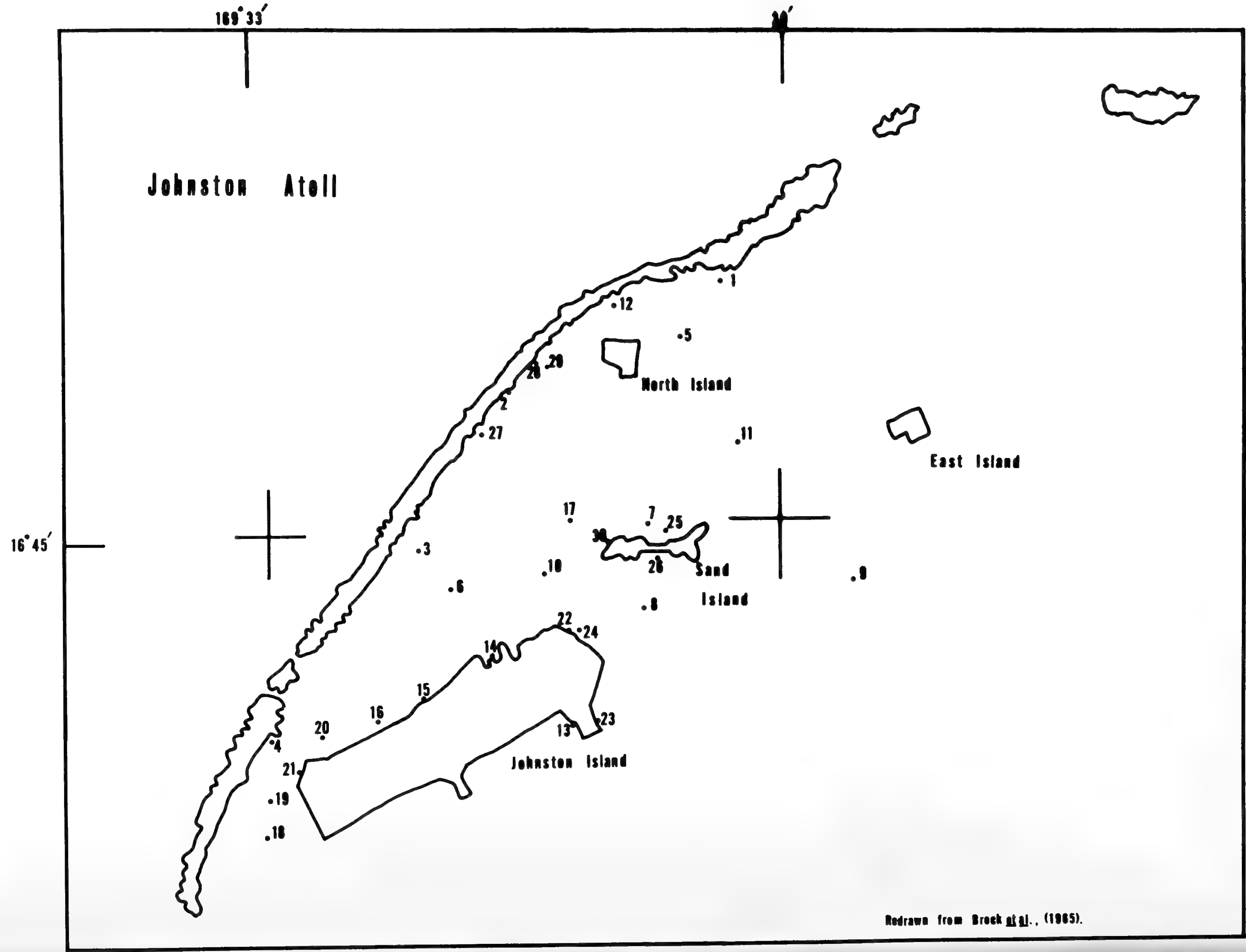
by Richard G. Buggeln and Roy T. Tsuda

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D. C., U. S. A.

March 30, 1969



Redrawn from Brock et al., (1965).

A RECORD OF BENTHIC MARINE ALGAE FROM JOHNSTON ATOLL

by Richard G. Buggeln[2/] and Roy T. Tsuda[3/]

A record of the genera of benthic marine algae was compiled as a part of a study of the effects of dredging on the marine environment on Johnston Atoll (Brock, et al., 1966). The preliminary species list (Buggeln & Tsuda, 1966) has been supplemented with collections made during a trip to Johnston Atoll, June 14-24, 1966, sponsored by the Department of Radiation Biology, University of Washington, Seattle. There appears to be no published account of the marine algae from Johnston Atoll, save for Halimeda tuna (Ell. & Sol.) Lamx. cited in Moul (1964). The present listing is conspicuously incomplete in some areas (e.g., the Melobesioid algae) and subsequent collections will necessitate additional entries as well as amendments to this list. Knowledge of the flora from this isolated atoll may serve to link other tropical and sub-tropical Pacific atolls whose floras have been reported (see Tsuda, 1966) with the major Hawaiian archipelago to the north.

Acknowledgments

We participated in programs sponsored by both the Zoology Department of the University of Hawaii and the Radiation Ecology Laboratory of the University of Washington; and we are indebted to Dr. Philip Helfrich, Associate Director, Hawaii Institute of Marine Biology, and Dr. Allyn H. Seymour, Director, Radiation Ecology Laboratory. We are grateful for the use of the personal libraries of

---

1/ Earlier portions of this study appeared in Hawaii Institute of Marine Biology, Technical Report #11 [Second Annual Report, AEC contract number AT (26-1)-90] and in Technical Report #9 from the same laboratory. Collections were also obtained under AEC contract #AT (26-1)-269 to the Radiation Ecology Laboratory, University of Washington, Seattle, Washington 98105.

Present Addresses:

2/ Botany Department, University of Washington, Seattle, Washington 98105

3/ Biology Department, College of Guam, Agana, Guam 96910

Drs. Maxwell S. Doty and Albert J. Bernatowicz, both of the University of Hawaii and Dr. Richard E. Norris of the University of Washington. Special thanks are given to specialists who aided in some of the determinations: Dr. E. Yale Dawson (Dasya, Callithamnion); Dr. W. Jan Newhouse, University of Hawaii (Cyanophyta); and Dr. George Hollenberg, Emeritus, University of Redlands, who incorporated our collections of Polysiphonia and Herposiphonia into a monograph of these genera from the central Pacific Ocean. Lastly, we greatly appreciate the effort shown by the collectors whose names appear throughout a following section, "Description of Stations."

Description of Johnston Atoll

"Johnston Atoll is located at 16° 15' N. Lat. and 169° 30' W. Long. It is 450 miles southwest of the nearest island in the Hawaiian chain, 700 miles northwest of the nearest of the Line Islands, and 1300 miles east of the Marshall Islands" (Gosline, 1955).

The extensive reef area has its long axis oriented in a northeast-southwest direction which essentially places the shoal parallel to the prevailing northeast trade winds. The shoal area which is approximately nine to ten miles long and seven to eight miles wide can be separated into three major regions: 1) the marginal reef, a narrow stip, frequently awash, which forms part of the northern, all of the northwestern, and part of the eastern boundary of the shoal; 2) the land masses, the natural islets of Johnston and Sand Islands and the two recently man-made islets called North and East Islands; and 3) the shoal, the extensive submerged coral area behind the marginal reef and surrounding the islets (Brock, *et al*., 1965).

Description of Stations

A very brief description of the stations from which the collections were made is given below. The location of each station is also indicated on the accompanying map of Johnston Atoll (Figure 1).* The collection numbers are part of a continuous series initiated by one of us (RT). The collection will be deposited in the herbarium of Dr. Maxwell S. Doty, Department of Botany, University of Hawaii, Honolulu, Hawaii 96822.

Station 1 - Algae growing on living *Porolithon* and *Acropora*** (1-3 meters depth) just inside the seaward reef, northeast of North Island. August 17, 1965. Collected by R. G. Buggeln and A. E. Murchison. (RT #1021-1070).

---

*Adapted from Brock *et*. *al*., (1965).

**Zoocorals whose apices are inhabited by the living polyps are here referred to as "living" coral. (The algae only grow on the basal exoskeleton which is non-living). We distinguish this latter habitat from that (*i.e.*, "dead coral") in which all of the living tissue has been killed and therefore one finds algae growing on the outermost tips of the exoskeleton.

Station 2 - Algae growing on well-developed coral heads (1-5 meters depth) in an are 25-30 meters inside the marginal reef, opposite and north of Johnston Island. August 19, 1965. Collected by R. G. Buggeln. (RT #1071-1101).

Station 3 - (A) - Algae growing on living Porolithon and Pocillopora were collected (2-3 meters depth) from the top of a large coral knoll about 5 meters in height in an area opposite and north of Johnston Island. August 20, 1965. Collected by A. E. Murchison. (RT #1102-1134).

(B) - Algae were collected from the lower 2 meters of the same coral knoll and were found mainly on dead** Pocillopora. August 20, 1965. Collected by A. E. Murchison (RT #1135-1144).

Station 4 - Algae collected on dead Pocillopora in turbid water (1 meter depth) just inside the seaward reef in an area northwest of the southwest end of Johnston Island. August 20, 1965. Collected by R. G. Buggeln. (RT #1145-1162).

Station 5 - (A) - Algae were collected on living Porolithon and Pocillopora (2 meters depth) in an area approximately 750 meters due east of the north end of North Island. August 18, 1965. Collected by R. G. Buggeln. (RT #1163-1185).

(B) - Algae collected on a silt-rubble bottom partially composed of small cobbles and dead Pocillopora fragments in about 15 meters of water. August 18, 1965. Collected by W. F. Van Heukelem. (RT #1186-1196).

Station 6 - (A) - Algae collected from the top 4 meters of a reef (along a mostly vertical transect) in an area north of Johnston Island. August 20, 1965. Collected by R. G. Buggeln. (RT #1197-1221).

(B) - Algae collected from dead Pocillopora near the bottom portion of the reef (7 meters depth) along the transect. August 20, 1965. Collected by A. E. Murchison. (RT #1222-1234).

Station 7 - Algae collected from dead coral (1-3 meters depth) in an area north of Sand Island. August 18, 1965. Collected by R. G. Buggeln. (RT #1235-1255).

Station 8 - (A) - Algae growing mainly on dead Pocillopora (2-4 meters depth) in an area south of Sand Island. August 18, 1965. Collected by R. G. Buggeln. (RT #1256-1269).

(B) - Algae collected on dead Pocillopora from the top of a coral head (1 meter depth). August 21, 1965. Collected by W. F. Van Heukelem. (RT #1270-1275).

Station 9 - Algae growing mainly on dead Pocillopora (2-3 meters depth) in an area about two miles east of Johnston Island. August 19, 1965. Collected by R. G. Buggeln. (RT #1275-1281).

Station 10 -(A) - Algae collected from a transect line on the bottom of a dredged channel (12-13 meters depth) composed of silt and small cobbles in an area west of Sand Island. August 19, 1965. Collected by A. E. Murchison. (RT #1282-1288).

(B) - Algae growing mainly on dead Pocillopora (4-13 meters depth) collected from the sides and bottom of the ship channel. August 19, 1965. Collected by D. Knowles. (RT #1289-1297).

(C) - Additional collections made at random on the bottom of the ship channel (12-13 meters depth). August 19, 1965. Collected by W. F. Van Heukelem. (RT #1298-1300).

Station 11 -(A) - Algae growing mainly on dead Pocillopora on the side of the ship channel (2-4 meters depth) in an area southwest of East Island. August 19, 1965. Collected by R. G. Buggeln. (RT #1301-1315).

(B) - Additional collections from the side of the ship channel were made between 3-5 meters depth. August 19, 1965. Collected by W. F. Van Heukelem. (RT #1316-1321).

(C) - Algae collected from the bottom of a generally barren channel area (6 meters depth). August 19, 1965. Collected by A. E. Murchison. (RT #1322-1326).

Station 12 -Algae collected from the top of the marginal reef bench (awash during all tidal periods) in an area north of North Island. August 22, 1965. Collected by R. G. Buggeln. (RT #1327-1343).

Station 13 -Algae collected from concrete blocks and scrap metal in the littoral zone on the southeast side of Johnston Island. December 19, 1965. Collected by R. T. Tsuda and R. G. Buggeln. (RT #1346-1348).

Station 14 -Algae collected from the concrete landing ramp in the littoral zone on the northwest shore of Johnston Island. December 21, 1965. Collected by R. G. Buggeln. (RT #1349-1350).

Station 15 -Algae growing on coral rubble in the littoral zone along the northwest shore of Johnston Island. July 15 and 19, 1966. Collected by R. G. Buggeln and Dr. Allyn H. Seymour. (RT #1462-1472).

Station 16 -Algae collected from the top of a submerged coral head (1-2 meters depth) 3-4 meters off the northwest shore of North Island. July 16, 1966. Collected by R. G. Buggeln. (RT #1473-1496).

Station 17 -Floating gelatinous masses collected in the ship channel opposite Sand Island, between North and Johnston Islands. July 16, 1966. Collected by R. G. Buggeln. (RT #1497).

Station 18 - Algae growing on a floating channel marker at the southwest end of Johnston Island. July 16, 1966. Collected by R. G. Buggeln. (RT #1498-1502).

Station 19 - Algae floating in the ship channel near the southwest end of Johnston Island. July 16, 1966. Collected by R. G. Buggeln. (RT #1504;1542).

Station 20 - Algae collected from the top of a coral head (1 meter depth) 100 meters from shore near the southwest end of Johnston Island opposite the break in the marginal reef. July 16, 1966. Collected by Dr. E. E. Held, J. S. Isakson, and R. G. Buggeln. (RT #1503; 1505; 1598-1611).

Station 21 - Algae growing on coral fragments in the littoral zone along the southwest shore of Johnston Island. July 17, 1966. Collected by R. G. Buggeln. (RT #1531-1541).

Station 22 - Algae collected near shore (1 meter depth) along the northeast shore of Johnston Island, opposite Sand Island. July 18, 1966. Collected by J. Isakson and R. G. Buggeln. (RT #1543-1546).

Station 23 - Algae growing in the littoral zone along the northeast side of the northernmost jetty on the southeast side of Johnston Island. July 18, 1966. Collected by J. Isakson and R. G. Buggeln. (RT #1547-1567).

Station 24 - Algae collected (1-2 meters depth) from the ridges of coral heads which abut the beach at the northeast end of Johnston Island. July 18, 1966. Collected by R. G. Buggeln. (RT #1568-1581).

Station 25 - Mats of algae growing in 3 meters of water, 30 meters off the north shore of Sand Island. July 20, 1966. Collected by R. G. Buggeln. (RT #1582).

Station 26 - Algae collected from a sandy bottom (1 meter depth) 50 meters from the south shore of the isthmus which separates the two larger land masses of Sand Island. July 20, 1966. Collected by J. S. Isakson and R. G. Buggeln. (RT #1583-1591).

Station 27 - Algae collected (1-2 meters depth) 75 meters inside the marginal reef and 2,000 meters southwest of North Island. July 22, 1966. Collected by R. G. Buggeln. (RT #1612-1634).

Station 28 - Algae collected on the marginal reef (awash here during all tidal periods) 1,000 meters southwest of North Island. July 22, 1966. Collected by R. G. Buggeln. (RT #1635-1662).

Station 29 - Algae collected (1-2 meters depth) 75 meters inside the marginal reef and 1,000 meters southwest of North Island. July 22, 1966. Collected by P. R. Olson. (RT #1663-1670).

Station 30 - Algae growing on coral rubble in the littoral zone near the western end of Sand Island. July 20, 1966. Collected by R. G. Buggeln. (RT #1593-1597).

Systematic list

The following is an annotated list of the marine benthic algae collected on Johnston Atoll. Some of the determinations, especially in the Rhodophyta, should be considered tentative until further study can be made on additional material. Much of the difficulty in identification can be attributed to the herbivorous predators. Certain algae are heavily grazed and fragmentary collections prevent positive identification in many cases.

CYANOPHYTA

Anacystis dimidiata (Kütz.) Drouet and Daily, 1956: 70.
Stations: 7 (RT #1235), 10a (RT #1284).
These cells are interspersed among the filaments of Schizothrix calcicola (Ag.) Gomont.

Entophysalis deusta Drouet and Daily, 1956: 193, Fig. 191.
Stations: 14 (RT #1350), 15 (RT #1465a), 24 (RT #1569b).
This species occurs as a dark green coating on coral and is mixed with Calothrix scopulorum Born. and Flah.

Schizothrix calcicola (Ag.) Gomont, 1892: 15, 307; Drouet, 1963: 275.
Stations: 1 (RT #1057), 2 (RT #1096), 3a (RT #1127a), 5a (RT #1183), 6b (RT #1222), 7 (RT #1235), 10a (RT #1284), 11a (RT #1305), 11c (RT #1326b), 15 (RT #1465d), 17 (RT #1497), 20 (RT #1514b), 21 (RT #1541a), 22 (RT #1546b), 24 (RT #1569c), 26 (RT #1591), 28 (RT #1643).
These collections appear as large gelatinous mats, thin sheets, or large clumps which are often greenish-white or red in color. The trichomes are about 1 μ in diameter; the individual cells are 1-3 μ long.

Hydrocoleum lyngbyaceum Gomont, 1892: 15, 337; Umezaki, 1961: 27.
Stations: 21 (RT #1540), 28 (RT #1655), 30 (RT #1594).

Microcoleus chthonoplastes Gomont, 1892: 15, 353; Tilden, 1910: 155.
Stations: 3a (RT #1111), 5a (RT #1183), 6b (RT #1230), 7 (RT #1235), 11a (RT #1306).
The bundles of trichomes are within large single sheaths; the individual trichomes are about 1.5 to 3.5 μ in diameter.

Microcoleus tenerrimus Gomont, 1892: 15, 355; Tilden, 1910: 155.
Stations: 16 (RT #1494), 27 (RT #1634).

Microcoleus vaginatus Gomont, 1892: 15, 355, Drouet, 1962: 204.
Station: 4 (RT #1149).

Lyngbia aestuarii Gomont, 1892 :15, 127; Tilden, 1910: 120.
Stations: 7 (RT #1235), 20 (RT #1514a), 28 (RT #1651).
These filaments are intermixed with Schizothrix calcicola (Ag.) Gomont. The trichomes are 6-7 μ in diameter; the sheathes measure 2.5 μ in thickness.

Lyngbya confervoides Gomont, 1892: 16, 136; Tilden, 1910: 119.
Stations: 7 (RT #1246).

Lyngbya lutea Gomont, 1893: 16, 141; Tilden, 1910: 114.
Station: 6b (RT #1230).
The collection consists of a few filaments and the determination is tentative.

Lyngbya majuscula Gomont, 1893 :16, 131; Tilden, 1910: 123.
Stations: 1 (RT #1049a), 6b (RT #1225b), 7 (RT #1251b), 10a (RT #1284), 10b (RT #1289), 11a (RT #1360), 11b (RT #1321), 11c (RT #1326a), 20 (RT #1606), 25 (RT #1582).
All of the collections appear as dark green, tangled filaments. A thick colorless sheath surrounds the trichomes; the latter are 22-30μ in diameter.

Spirulina tenerrima Gomont, 1893: 16, 252; Tilden, 1910: 88.
Stations: 6b (RT #1222), 21 (RT #1541c).
A few of these spiral filaments are mixed with Schizothrix calcicola (Ag.) Gomont. The trichomes are about 6μ in diameter. The width of the spirals is about 1.5μ; the distance between turns is about 1μ.

Symploca atlantica Gomont, 1893: 16, 109; Tilden, 1910: 129.
Stations: 22 (RT #1543), 28 (RT #1655).

Oscillatoria nigroviridis Gomont, 1893: 16, 217; Tilden, 1910: 69.
Station: 14 (RT #1349b).
This species is epiphytic on Sphacelaria novaehollandiae Sonder. The trichomes are about 12μ in diameter.

Phormidium submembranaceum Gomont, 1893: 16, 180; Tilden, 1910: 104.
Stations: 1 (RT #1047), 2 (RT #1096), 5b (RT #1190), 10b (RT #1292), 11b (RT #1320), 12 (RT #1331), 24 (RT #1569a).

Hormothamnion enteromorphoides Bornet and Flahault, 1888: 260; Tilden, 1910: 205.
Stations: 8b (RT #1272), 11b (RT #1321), 21 (RT #1531).
The mass of entangled filaments is greenish-white in color. The individual trichomes are about 5μ in diameter with intercalary heterocysts present.

Calothrix crustacea Bornet and Flahault, 1886: 359; Tilden, 1910: 264.
Stations: 7 (RT #1251b), 11a (RT #1308), 11b (RT #1321), 11c (RT #1325a).
In these collections, the species is associated with Lyngbya majuscula Gomont. The unbranched trichomes are 8-12μ in diameter with numerous heterocysts present.

Calothrix scopulorum Bornet and Flahault, 1886: 353; Tilden, 1910: 258.
Stations: 1 (RT #1047), 2 (RT #1055), 3a (RT #1127a), 4 (RT #1148), 6a (RT #1200), 6b (RT #1228b), 7 (RT #1246), 8a (RT #1261), 14 (RT #1350), 15 (RT #1465b), 18 (RT #1501), 21 (RT #1541b).

The majority of the collections is found to encrust coral. Each tapering trichome consists of a single enlarged basal heterocyst. The cells of the trichomes are 5-10μ in diameter at the base and a distinct sheath is present. In his revision of the genus, Fan (1956) treats this entity as Calothrix confervicola (Roth) Agardh.

Isactis plana Bornet and Flahault, 1886: 344; Tilden, 1910: 281.
Stations: 15 (RT #1465c), 21 (RT #1536), 22 (RT #1546), 23 (RT #1559), 24 (RT #1576), 27 (RT #1622), 28 (RT #1641a), 30 (RT #1593).

CHLOROPHYTA

Palmogloea protuberans (Sm. & Sew.) Kützing, 1843: 176.
Station: 24 (RT #1568).
Cells are about 5μ in diameter and irregular in shape.

Enteromorpha kylinii Bliding, 1948: 1; Bliding, 1963: 103.
Station: 13 (RT #1347).
The thalli are 45-210μ in diameter with branching, when present, only near the base. The cells, arranged in longitudinal but not in transverse rows, are usually rectangular but at times polygonal in shape and about 17μ long and 10μ wide. Two or more pyrenoids are present in each cell.

Cladophora crystallina (Roth) Kützing, 1845: 213; Dawson, 1956: 33.
Stations: 1 (RT #1048), 3a (RT #1144), 4 (RT #1154b), 5a (RT #1184b), 18 (RT #1499).
The filaments are about 1 cm high. The basal cells are about 90μ in diameter and the ultimate branches taper to about 60 in diameter. The pectinate branching as well as the enlarged basal portion are very characteristic of this species.

Cladophoropsis sp.
Station: 28 (RT #1648).
This single, small, matted specimen has filaments about 75μ wide.

Valonia ventricosa J. Ag., 1887: 96; Egerod, 1952: 347.
Station: 5a (RT #1169).
This collection consists of a single vesicle, 1 cm in diameter.

Dictyosphaeria versluysii Weber-van Bosse, 1905: 114; Egerod, 1952: 351.
Stations: 1 (RT #1023), 2 (RT #1098), 3a (RT #1122), 5a (RT #1181), 6a (RT #1212), 7 (RT #1250), 8a (RT #1257), 9 (RT #1274), 11a (RT #1310), 12 (RT #1344), 16 (RT #1481), 20 (RT #1513), 23 (RT #1548), 24 (RT #1570), 27 (RT #1619), 28 (RT #1644), 29 (RT #1667).
These solid, irregularly shaped, pseudoparenchymatous thalli range from 5 to 50 mm in breadth. The individual vesicles are approximately 1 mm in diameter; spinous trabeculae are present.

<u>Boodlea composita</u> (Harvey) Brand, 1904: 187; Egerod, 1952: 362.
Station: 1 (RT #1041).
This collection consists of a small spongiose mass about 1 cm in diameter.

<u>Microdictyon setchellianum</u> Howe, 1934: 38; Setchell, 1929: 553; Egerod, 1952: 366.
Stations: 2 (RT #1097), 3a (RT #1129), 5a (RT #1173), 7 (RT #1245), 12 (RT #1327), 27 (RT #1616), 28 (RT #1645), 29 (RT #1668).
Most of the specimens were immature, ranging from 20 mm to 5 cm in breadth. The cell walls, about 25μ in thickness, distinguish the species from <u>M. okamurai</u> Setchell which is said to have a thinner cell wall.

<u>Derbesia marina</u> (Lyngbye) Solier, 1847: 158; Dawson, 1956: 34.
Station: 19 (RT #1504 & 1542).

<u>Derbesia</u> sp.
Stations: 10a (RT #1286), 10b (RT #1293a).
This species occurs in mats throughout Station 10. The filaments are about 15 cm long and dichotomously branched. The diameter of the filaments is about 37μ. Since all of the collections are sterile, we are tentatively placing these specimens in this genus.

<u>Caulerpa ambigua</u> Okam., 1897: 4.
Stations: 4 (RT #1152), 7 (RT #1249), 8a (RT #1260a, 1260b), 16 (RT #1488), 20 (RT #1509).
All of the collections are about 2 mm high with distichously arranged ramuli. The ramuli in specimen RT #1206b are branched in a verticillate manner.

<u>Caulerpa racemosa</u> var. <u>macrophysa</u> (Kütz.) Taylor, 1928: 101; Eubank, 1946: 420.
Station: 5a (RT #1170).
The stolons are about 3.5 cm long and the ramuli about 1.5 cm high.

<u>Caulerpa urvilliana</u> Montagne, 1845: 21; Taylor, 1950: 60.
Stations: 1 (RT #1021), 8a (RT #1263), 8b (RT #1270), 12 (RT #1345), 26 (RT #1583), 28 (RT #1636).
These collections consist of rather large specimens with stolons up to 40 cm in length; two forms of this species are present in our collections.

<u>Bryopsis pennata</u> Lamx., 1809: 134; Egerod, 1852: 370.
Stations: 1 (RT #1044a), 2 (RT #1087), 4 (RT #1154a), 5a (RT #1184c), 6a (RT #1215), 7 (RT #1237), 8a (RT #1266), 10a (RT #1283), 10c (RT #1299), 13 (RT #1348), 16 (RT #1478), 20 (RT #1522 & 1601), 23 (RT #1553), 27 (RT #1626), 28 (RT #1650).

Two morphological forms exist in these collections. The first is similar to the description and illustration in Egerod (1952) while the other form has long branches, distichously arranged, at the upper portion of the main axis.

Pseudochlorodesmis parva Gilbert, 1962: 141.
Stations: 2 (RT #1089), 12 (RT #1337).

The above collections appear as green felt on corals and attain a height of 5 mm. These siphonaceous filaments are erect and branch only once at the upper portion. The filaments are about 21μ wide and the rhizoids are conspicuously beaded. The following collections are tentatively placed here: (RT #1477), (RT #1508), and (RT #1562). These are from stations: 16, 20, and 23, respectively.

Codium arabicum Kütz., 1856: 35, Egerod, 1952: 382.
Station: 2 (RT #1075).

This unbranched mass of utricles measures about 1 cm in breadth. The utricles are long and clavate and measure up to 900μ in length with the width varying from 150μ at the base to 225μ above. Secondary and tertiary utricles are very common.

Codium sp.
Stations: 1 (RT #1035), 2 (RT #1073), 3a (RT #1127b), 5a (RT #1174), 15 (RT #1463), 16 (RT #1496), 23 (RT #1556), 24 (RT #1572), 27 (RT #1613).

The collections of branched fragments range from 5-20 mm in length. The medullary filaments are about 30μ in diameter. The utricles are approximately 375μ in length and 255μ in width and appear slightly oblong in shape. Secondary utricles are present in specimen RT #1035. Although fragmentary, the specimens have characteristics of C. edule Silva.

Halimeda discoidea Decaisne, 1842: 91; Hillis, 1959: 352.
Stations: 1 (RT #1022a), 3a (RT #1102), 6a (RT #1213), 16 (RT #1474), 28 (RT #1635), 29 (RT #1663).

This species is characterized by its inflated secondary utricles.

Halimeda tuna (Ellis and Solander) Lamx., 1812: 186; Hillis, 1959: 342.
Stations: 1 (RT #1022b), 12 (RT #1343).

All of our collections of Halimeda were rather similar in external appearance, therefore anatomical characteristics, i.e., size and shape of the utricles, etc., are the bases for our decisions.

Aside from the specimens cited above, a very immature thallus consisting of only two segments was collected at Station 2 (RT #1083).

Acetabularia clavata Yamada, 1934: 57; Egerod, 1952: 413.
Stations: 20 (RT #1611), 24 (RT #1581).

Acetabularia mobii Solms-Laubach, 1895: 30; Egerod, 1952: 411.
Stations: 2 (RT #1076a), 4 (RT #1145), 5a (RT #1164), 5b (RT #1192), 6a (RT #1209), 20 (RT #1523), 23 (RT #1565a), 27 (RT #1620).

These "umbrella-shaped" thalli are 4-6 mm high with the disc about 1.5 mm in diameter. Each corona knob may have 3-6 sterile hairs.

Acetabularia tsengiana Egerod, 1952: 414.
Station: 23 (RT #1565b).

Acetabularia sp.
Stations: 2 (RT #1076), 30 (RT #1597).

These specimens are 3-6 mm high and bear five very inflated gametangial rays; the disc is about 1.5 mm in diameter.

CHRYSOPHYTA

Ostreobium reineckei Bornet, in Reinbold, 1896: 269; Dawson, 1954: 396.
Stations: 16 (RT #1484), 23 (RT #1563).

This minute filamentous alga is embedded in coral and gives a greenish tinge to the peripheral matrix. Although we only record this alga from two stations, it (or another species) is probably ubiquitous along with Entophysalis deusta Drouet and Daily.

PHAEOPHYTA

Ectocarpus breviarticulatus J. Ag., 1847: 7; Boergesen, 1914: 17; Dawson, 1954: 398.
Stations: 13 (RT #1346), 18 (RT #1500), 23 (RT #1564).

These spongiose clumps are about 2 cm long. The hook-like branches, characteristic of this species, contribute to the interwoven appearance. The semi-oval plurilocular sporangia are about 42μ long and 36μ wide and are supported by short pedicels approximately 25μ long and 10μ wide.

Ectocarpus indicus Sonder, in Zollinger, 1854: 3, Boergesen, 1941: 16.
Stations: 2 (RT #1084), 3a (RT #1116), 4 (RT #1147), 5a (RT #1176), 6a (RT #1211), 7 (RT #1238), 12 (RT #1336), 16 (RT #1590), 21 (RT #1539), 22 (RT #1544), 24 (RT #1580a).

The above collections are placed in this taxon although some of them may be referrable to Ectocarpus mitchellae Harvey. The filaments are 5 mm high and about 17μ wide. The oblong plurilocular sporangia occurring on these specimens range from 70-240μ in length and are about 25μ wide.

Ectocarpus irregularis Kützing, 1845: 234; Dawson, 1954: 398.
Station: 15 (RT #1467).

Ectocarpus sp.
Station: 10c (RT #1298).

The cells of the filaments are about 20μ wide and 20-40μ long. The pyriform plurilocular organs are about 38μ long and 32μ wide at the base.

Sphacelaria furcigera Kützing, 1855 (Tab. Phyc. 5); Boergesen, 1941: 46.
Stations: 5b (RT #1189), 24 (RT #1580).
This species is characterized by its Y-shaped propagulae. The filaments are about 5 mm high and 30μ wide.

Sphacelaria novaehollandiae Sonder, 1845: 50; Boergesen, 1941: 45.
Stations: 2 (RT #1088), 3b (RT #1142), 5a (RT #1179), 7 (RT #1254), 9 (RT #1277), 14 (RT #1349), 28 (RT #1652).
All of the specimens cited above have propagulae which are characteristic of this species.
Many of our *Sphacelaria* collections are sterile and application of a specific epithet is difficult. The following sterile specimens are recorded with their locations: 1 (RT #1033), 3a (RT #1113), 6a (RT #1218), 6b (RT #1223), 8a (RT #1267), 10b (RT #1291), 11a (RT #1311), 11b (RT #1316), 11c (RT #1324), 12 (RT #1333), 16 (RT #1486), 20 (RT #1600), 22 (RT #1545), 24 (RT #1575), 29 (RT #1666), 30 (RT #1595).

Sphacelaria tribuloides Meneghini, 1840: 2; Boergesen, 1941: 41.
Station: 15 (RT #1470).

Dictyota sp.
Stations: 1 (RT #1038), 3a (RT #1123), 20 (RT #1520), 27 (RT #1633).
These specimens are mere fragments (5 mm long) and specific determination is not possible.

Pocockiella variegata (Lamx.) Papenfuss, 1943: 467.
Stations: 1 (RT #1027), 2 (RT #1077), 3a (RT #1124), 3b (RT #1141),
4 (RT #1151, 5a (RT #1178), 5b (RT #1186), 6a (RT #1199),
4 (RT #1151), 5a (RT #1178), 5b (RT #1186), 6a (RT #1199
#1199), 6b (RT #1234), 9 (RT #1273), 10b (RT #1296), 12 (RT #1340), 16 (RT #1472), 20 (RT #1507), 23 (RT #1552), 27 (RT #1662), 29 (RT #1670).
These collections consist of thalli up to several centimeters in breadth. At times this species could be seen growing as a collar around living corals with the basal portion of the thallus firmly attached to exoskeleton subtending the living apex. Frequently this alga acts as a substratum for other filamentous species.

RHODOPHYTA

Asterocystis ornata (Ag.) Hamel, 1924: 451; Dawson, 1954: 411.
Station: 6a (RT #1203).
This species is usually found as an epiphyte on larger filamentous algae; it is encountered at many stations.

Goniotrichum alsidii (Zanardini) Howe, 1920: 553; Taylor, 1960: 288.

Station: 11b (RT #1319).

These fine golden-colored filaments are epizoic on Pennaria. The dense habit obscures the basal portion of the alga. The gelatinous branches are up to 25μ in diameter with the cells 9μ wide and 9-14μ in length. The specimens appear to be in agreement with Taylor's description.

Erythrotrichia sp.

Station: 6a (RT #1198).

One or more species of these tiny epiphytes are commonly found on larger algae.

Gelidium crinale var. perpusillum Piccone and Grunow, in Piccone, 1884b: 317; Dawson, 1954: 421.

Stations: 3a (RT #1128), 3b (RT #1136), 5b (RT #1169), 11a (RT #1304), 11c (RT #1323), 16 (RT #1491), 20 (RT #1602b), 23 (RT #1551), 26 (RT #1587).

The habit and apical cell represented in Dawson's figure are characteristic of these collections.

Gelidium pusillum (Stackh.) Le Jolis, 1864: 139; Dawson, 1954: 420; var. pusillum Dawson, 1961: 434.

Stations: 3a (RT #1131), 5a (RT #1182), 6a (RT #1216), 7 (RT #1243), 8a (RT #1262), 14 (RT #1464), 20 (RT #1602a), 21 (RT #1534a), 26 (RT #1856).

One or more erect flattened blades about 5 mm in length arise at "nodes" from a prostrate axis. The rhizoidal holdfasts occur at varying intervals along the prostrate axis. Tetrahedral tetraspores are borne on the erect axis or on short lateral blades (RT #1131).

Wurdemania sp.

Stations: 1 (RT #1034), 4 (RT #1155b), 8a (RT #1258), 20 (RT #1511a), 24 (RT #1577), 28 (RT #1659).

These collections are tentatively placed in this genus. The habit of the collections is lax. There is no apical cell present and the medulla is multiaxial. Without fertile material, some difficulty arises in distinguishing members of Wurdemania from Gelidiopsis.

Jania capillacea Harvey, 1853: 84; Dawson, 1954: 432.

Stations: 1 (RT #1028), 3a (RT #1118a), 3b (RT #1135), 4 (RT #1146b), 6a (RT #1200a), 7 (RT #1252a), 8a (RT #1286a), 9 (RT #1276), 10b (RT #1294a), 11a (RT #1308), 12a (RT #1330), 20 (RT #1519b), 23 (RT #1566a), 26 (RT #1585b).

This small alga is often encountered. The diameter of the axes ranges from 35 to 65μ.

Jania decussato-dichotoma (Yendo) Yendo, 1905: 37; Dawson, 1956: 49.

Stations: 2 (RT #1092b), 3a (RT #1118b), 4 (RT #1156b), 6a (RT #1200b), 20 (RT #1519a), 23 (RT #1566b), 26 (RT #1585a), 27 (RT #1625), 28 (RT #1660a).

337-682 O-69—2

This alga is characterized by its small size and decussate branching pattern. The diameter of the branches ranges from 100 to 110μ. The alga is frequently associated with *J. capillacea.*

Amphiroa sp.
Stations: 1 (RT #1025a), 3a (RT #1118c).
This short, articulated coralline is 1 - 1.5 cm in height and 0.1 cm wide with conspicuous nodal constrictions between heavily calcified internodes. Several short laterals are present.

Hypnea esperi Bory, 1829: 157; Boergesen, 1920: 306; Dawson, 1954: 436.
Stations: 1 (RT #1053-cystocarpic), 2 (RT #1079), 3a (RT #1115-cystocarpic), 3b (RT #1138-cystocarpic), 4 (RT #1153-cystocarpic), 5a (RT #1177-tetrasporic and cystocarpic), 6a (RT #1198a), 7 (RT #1255-tetrasporic), 8a (RT #1258-tetrasporic), 16 (RT #1489-tetrasporic), 20 (RT #1528), 23 (RT #1547-tetrasporic), 24 (RT #1570), 28 (RT #1640a).
These small laxly clumped collections (branches not anastomosing with each other) agree with the descriptions and figures in Boergesen and Dawson.

Lomentaria hakodatensis Yendo, 1920: 6; Dawson, 1956: 52; (*Lomentaria sinensis* Howe, 1924: 139).
Stations: 1 (RT #1037b-tetrasporic, 1059b-tetrasporic and some cystocarpic), 7 (RT #1236b), 8a (RT #1264-tetrasporic), 21 (RT #1538).
This alga is characterized by the creeping prostate habit and terete, indeterminate axes which often anastomose with other axes or attach to the substratum. Erect, nonbranching axes bear the tetrasporangia. Fragmentary collections recorded at stations 20 and 28 may be referred to this taxon.

Champia parvula (Ag.) Harvey, 1853: 76; Dawson, 1954: 432.
Stations: 1 (RT #1052-cystocarpic), 2 (RT #1071).
These specimens are entangled with *Hypnea esperi* Bory and are frequently attached to the latter and to sand grains. The largest specimen is 70.5 mm.

Antithamnion antillarum Boergesen, 1917: 226; Taylor, 1960: 499.
Stations: 1 (RT #1024-tetrasporic), 2 (RT #1089b), 6a (RT #1198c), 7 (RT #1236a), 16 (RT #1493-tetrasporic).
Our material fits the description in Taylor quite well.

Callithamnion marshallensis Dawson, 1957: 118.
Stations: 12a (RT #1335-tetrasporic), 16 (RT #1475), 23 (RT #1567b), 29 (RT #1661a).

Callithamnion sp.
Station: 4 (RT #1160a).

Centroceras apiculatum Yamada, 1944: 42; Dawson, 1956: 55.
Stations: 1 (RT #1049-tetrasporic), 2 (RT #1078), 3a (RT #1109), 3b (RT #1139), 4 (RT #1146a), 5a (RT #1167a-tetrasporic),

6a (RT #1206), 7 (RT #1252b), 8a (RT #1268a), 9 (RT #1279), 16 (RT #1473e), 20 (RT #1510), 23 (RT #1550b), 24 (RT #1573), 27 (RT #1612), 28 (RT #1639), 30 (RT #1588).

This species is a conspicuous element in many of the collections.

Centroceras clavulatum (Ag.) Montagne, in Durieu, 1846: 140; Dawson, 154: 446.

Stations: 1 (RT #1028b), 9 (RT #1281c), 10a (RT #1285), 10b (RT #1294b), 11b (RT #1317), 20 (RT #1610), 30 (RT #1584c).

This species is not as common as C. apiculatum Yamada but is easily recognized by the presence of short spines at the apical terminus of each cortical band.

Crouania minutissima Yamada, 1944: 41; Dawson, 1956: 55.

Station: 29 (RT #1660b).

Ceramium affine Setchell and Gardner, 1930: 172; var. originale Dawson, 1950: 132.

Stations: 2 (RT #1089a), 3a (RT #1104), 4 (RT #1140a-tetrasporic), 5b (RT #1191a), 6a (RT #1259b), 9 (RT #1281b), 11b (RT #1318-cystocarpic), 23 (RT #1557b), 26 (RT #1584a), 27 (RT #1646b).

This species is commonly encountered as a small fragment in many of the collections. Its thin diameter, long internodes, and characteristic cortication are distinctive features.

Ceramium fimbriatum Setchell & Gardner, 1924: 777; Dawson, 1950: 123.

Station: 28 (RT #1646).

A single small specimen is tentatively placed in this taxon.

Ceramium gracillimum var. byssoideum (Harv.) G. Mazoyer, 1938: 323; Dawson, 1954: 448, figs. 55, e-f.

Stations: 1 (RT #1032-tetrasporic), 3a (RT #1158), 7 (RT #1240), 8a (RT #1259a), 8b (RT #1271), 9 (RT #1281a-cystocarpic), 11b (RT #1319a), 12a (RT #1328-tetrasporic), 16 (RT #1482b), 20 (RT #1515a), 21 (RT #1532a), 24 (RT #1571), 27 (RT #1623), 28 (RT #1646).

The characteristic nodal cortication--the cortical bands divided with the lower third composed of transversely elongated cells--is an obvious feature of this fairly common species.

Ceramium huysmansii Weber van Bosse, 1932: 322; Dawson, 1954: 446; Ceramiella huysmansii Boergesen, 1953: 47.

Stations: 1 (RT #1034a-cystocarpic), 2 (RT #1100), 3a (RT #1118d), 3b (RT #1139b), 4 (RT #1157), 5b (RT #1188b), 6a (RT #1220c), 16 (RT #1487b).

The generic name, Ceramiella, has been proposed for this taxon in recognition of its characteristic cortication which entirely covers the central axial cells.

Ceramium maryae Weber van Bosse, 1923: 324; Dawson, 1954: 448.

Station: 12a (RT #1328b).

A single specimen is tentatively placed in this taxon.

Ceramium vagabunde Dawson, 1957a: 121; Dawson, 1962: 66.
Stations: 1 (RT #1032c), 5a (RT #1167b-tetrasporic), 11a (RT #1313a), 12a (RT #1328c).

This material seems to fit the description and figures in Dawson with regard to cortication.

Ceramium zacae Setchell & Gardner, 1937: 89; Dawson, 1950: 134.
Stations: 20 (RT #1512 and 1582b), 23 (RT #1550a), 26 (RT #1584b), 27 (RT #1632).

Ceramium sp.
Stations: 3a (RT #1104a), 5b (RT #1188a).

Crouania minutissima Yamada, 1944: 41; Dawson, 1956: 55.
Stations: 29 (RT #1660b).

Griffithsia metcalfii Tseng, 1942: 11, Abbott, 1946: 440; Dawson, 1954: 450.
Stations: 5b (RT #1191b), 6b (RT #1227-spermatangial and cystocarpic specimens).

The habit and tetrasporangial clusters agree with Abbott's description and figures.

Griffithsia ovalis Harvey, 1862: 203; Abbott, 1946: 2.
Station: 1 (RT #1054-tetrasporic).

This single fertile specimen is placed in this taxon because the involucral cells appear to arise from the main filament and not from the tetrasporangial branch as in G. metcalfii.

Griffithsia tenuis C. Agardh, 1828: 131; Abbott, 1946: 441, Dawson, 1954: 450.
Stations: 1 (RT #1044-tetrasporic), 4 (RT #1150c), 6a (RT #1204b), 16 (RT #1482a-cystocarpic), 20 (RT #1511a), 27 (RT #1624), 28 (RT #1649).

The vegetative cells are 60-100μ wide and 3-5(9) times as long as wide. There are no involucral cells substending the tetraspores which are clustered at the apex of short vegetative cells. The material agrees more closely with the taxon as described sensu Abbott than sensu Tseng (1942).

Griffithsia sp.
Station: 7 (RT #1242b).

The small collection from this station is most likely referable to one of the taxa above but it was too fragmentary for specific determination.

Dasya adherens Yamada, 1944: 31.
Stations: 3a (RT #1125), 28 (1647b-tetrasporic).

Dasya sinicola (S. & G.) Dawson var. sinicola Dawson, 1963: 408.
Stations: 1 (RT #1053b, 1056a, and 1058), 3b (RT #1135), 27 (1631a), 28 (1647a-tetrasporic).

Dasya sp.
Stations: 5a (RT #1185a), 8a (RT #1265), 12a (RT #1332).
The specimens appear to be juvenile stages of much larger forms.

Taenioma macrourum Thuret, in Bornet and Thuret, 1876: 69; Papenfuss, 1944: 1943.
Stations: 2 (RT #1093), 3a (RT #1107t), 5a (RT #1172), 17 (RT #1480).
The presence of two apical hairs distinguishes this species from T. perpusillum which has three.
Dr. G. J. Hollenberg (personal communication) has informed us that while sorting through the collections of Polysiphonia from this atoll, he came across several specimens of Taenioma which had both two and three apical hairs on different axes of a single specimen.

Caloglossa leprieurii (Montagne) J. Ag., 1876: 499; Post, 1936: 49, Dawson, 1956: 57.
Stations: 6a (RT #1205), 6b (RT #1224).
These tiny prostrate blades are attached to the substratum by rhizoidal outgrowths from the mid-rib. The erect blades usually arise from the mid-rib near a holdfast. The material is sterile.

Heterosiphonia wurdemanii var. laxa Boergesen, 1915-20: 326; Taylor, 1960: 565-6.
Stations: 1 (RT #1042), 3a (RT #1107a), 5a (RT #1171), 28 (RT #1647c-tetrasporic).

Herposiphonia spp.
Stations: 1 (RT #1060), 2 (RT #1090), 3a (RT #1104b), 5a (RT #1180), 6b (RT #1226), 7 (RT #1239), 27 (RT #1628), 28 (RT #1638), 20 (RT #1525).
These collections as well as the Polysiphonias have been identified by Dr. G. J. Hollenberg and are being treated separately in a monograph currently in preparation.

Polysiphonia spp.
Stations: 1 (RT #1061), 2 (RT #1080), 3b (RT #1139), 5a (RT #1185b), 6a (RT #1214), 7 (RT #1247), 9 (RT #1275), 10a (RT #1282), 10c (RT #1300), 11a (RT #1302), 11c (RT #1322), 12a (RT #1329), 16 (RT #1468), 17 (RT #1473a & 1497), 18 (RT #1503), 20 (RT #1524 & 1526), 21 (RT #1535), 23 (RT #1616).

Laurencia sp.
Stations: 1 (RT #1030b), 2 (RT #1081), 3a (RT #1106), 3b (RT #1137), 5a (RT #1166), 6a (RT #1207), 8a (RT #1269a), 12 (RT #1334), 17 (RT #1473d), 23 (RT #1549), 29 (RT #1669a).
Feeding herbivores leave nothing but the basal portions for collectors! "Undisturbed" material is needed before identifications can be attempted.

Chondria repens Boergesen, 1924: 300; Tanaka, 1963: 66.
Stations: 1 (RT #1030-tetrasporic), 2 (RT #1074), 3a (RT #1106), 5a (RT #1195), 6a (RT #1204c-tetrasporic), 28 (RT #1657), 29 (RT #1669-tetrasporic).

The habit of this alga and the morphological features of the tetrasporangia agree in detail with Tanaka's description and figures.

SELECTED BIBLIOGRAPHY

Abbott, I. A. 1946. The genus Griffithsia (Rhodophyceae) in Hawaii. Farlowia 2(4): 439-453.

Bliding, C. 1963. A critical survey of European taxa in Ulvales. Opera Botanica 8(3): 160 pp.

Boergesen, F. 1914. The marine algae of the Danish West Indies. Pt. 2. Phaeophyceae. Dansk Bot. Arkiv. 2(2): 157-224.

__________. 1915-1920. The marine algae of the Danish West Indies. Pt. 3. Rhodophyceae. Dansk Bot. Arkiv. 3(1): 1-504.

__________. 1941. Some marine algae from Mauritius. II. Phaeophyceae. K. Danske Vidensk. Selsk., Biol. Meddel. 16(3): 1-81, 8 pls.

__________. 1953. Some marine algae from Mauritius. V. K. Dansk Vidensk. Selsk., Biol. Meddel. 21(9): 1-62.

Brock, V. E., R. S. Jones and P. Helfrich. 1965. An ecological reconnaissance of Johnston Island and the effects of dredging. Hawaii Marine Laboratory Technical Report No. 5. University of Hawaii, Honolulu, Hawaii. 90 pp.

__________, W. Van Heukelem, & P. Helfrich. 1966. An ecological reconnaissance of Johnston Island and the effects of dredging. (Second Annual Report). Hawaii Institute of Marine Biology Technical Report No. 11. University of Hawaii, Honolulu. 56 pp.

Buggeln, R. G., & R. T. Tsuda. 1966. A preliminary marine algal flora from selected habitats on Johnston Atoll. Hawaii Institute of Marine Biology Technical Report No. 9. University of Hawaii, Honolulu. 29 pp.

Dawson, E. Y. 1950. A review of Ceramium along the Pacific Coast of North America with special reference to its Mexican representatives. Farlowia 4(1): 113-138.

__________. 1954. Marine plants in the vicinity of the Institute Océanographique de Nha Trang, Viet Nam. Pacific Sci. 8(4): 373-469, 1 map, 63 figs.

__________. 1956. Some marine algae of the southern Marshall Islands. Pacific Sci. 10(1): 25-66, 66 figs.

Dawson, E. Y. 1957. An annotated list of marine algae from Eniwetok Atoll, Marshall Islands. Pacific Sci. 11(1): 92-132, 31 figs.

__________. 1961. Plantas marinas de la zona de las mareas de El Salvador. Pacific Nat. 2(8): 288-461.

__________. 1962. Marine red algae of Pacific Mexico. Pt. 7. Ceramiales: Ceramiaceae, Delesseriaceae. Univ. So. Calif. Press 26(1): 1-106.

__________. 1963. Marine algae of Pacific Mexico. Pt. 8. Ceramiales: Dasyaceae, Rhodomelaceae. Nova Hedwigia 6(3/4): 401-481.

Drouet, F. 1962. Gomont's ecophenes of the blue-green alga, Microcoleus vaginatus (Oscillatoriaceae). Proc. Acad. Nat. Sci., Phil. 114(6): 191-205.

__________. 1963. Ecophenes of Schizothrix calcicola. Proc. Acad. Nat. Sci., Phil. 115(9): 261-281.

__________, and W. A. Daily. 1956. Revision of the coccoid Myxophyceae. Butler Univ. Bot. Studies, XII: 218 pp.

Egerod, L. E. 1952. An analysis of the siphonous Chlorophycophyta. Univ. Calif. Publ. Bot. 25(5): 325-454, 23 figs., 14 pls.

Eubank, L. L. 1946. Hawaiian representatives of the genus Caulerpa. Univ. Calif. Publ. Bot. 18(18): 409-432, 2 figs.

Fan, K. C. 1956. Revision of Calothrix Ag. I. Delineation of species. Rev. Algol. N. S. 2(3): 154-178.

Gilbert, W. J. 1962. Contribution to the marine Chlorophyta of Hawaii, I. Pacific Sci. 16(1): 135-444, 8 figs.

Gosline, W. A. 1955. The inshore fish fauna of Johnston Island, a central Pacific atoll. Pac. Sci. 9: 442-480.

Hillis, L. W. 1959. A revision of the genus Halimeda. Inst. Mar. Sci. VI: 321-403, 12 pl.

Howe, M. A. 1924. Chinese marine algae. Torrey Bot. Club Bull. 51: 133-144, 2 pls.

Kützing, F. T. 1843. Phycologia generalis. 458 pp., 80 pls. F. A. Brockhaus, Leipzig.

Moul, E. T. 1964. New records of Halimeda and Udotea for the Pacific area. Atoll Res. Bull. (106): 10 pp.

Okamura, K. 1897. On the algae of Ogasawara-jima (Bonin Isls.) Bot. Mag. Tokyo 11(119-120): 1-16.

Papenfuss, G. F. 1943. Notes on algal nomenclature. II. Gymnosorus J. Agardh. Amer. J. Bot. 30: 463-468, 15 figs.

__________. 1944. Structure and taxonomy of Taenioma, including a discussion of the phylogeny of the Ceramiales. Madrono 7(3): 193-214.

Post, E. 1936. Systematische und pflanzengographische Notizen zur Bostrichia-Caloglossa-Assoziation. Rev. Algologique 9(1-2): 1-84, 4 figs.

Tanaka, T. 1963. Studies on some marine algae from Southern Japan. IV. Mem. Fac. Fish., Kagoshima Univ. 12(1): 66-67.

Taylor, W. R. 1950. Plants of Bikini and other Northern Marshall Islands. Univ. Mich. Press. xv + 227 pp., 79 pls.

__________. 1960. Marine algae of the eastern tropical and subtropical coasts of the Americas. Univ. Mich. Press. ix + 870 pp., 14 figs., 80 pls.

Tilden, J. 1910. Minnesota algae. Vol. I. Report of the Survey, Botanical Series, VIII. Minneapolis, Minnesota. iv + 319 pp., 20 pls.

Tseng, C. K. 1942. On some Chinese species of Griffithsia. Mich. Acad. Sci., Arts and Letters, Papers 27: 111-116.

Tsuda, R. T. 1966. Preliminary bibliography on the marine benthic algae in the Central Pacific, Polynesia and Micronesia. Hawaii Institute of Marine Biology Technical Report No. 10. University of Hawaii, Honolulu. 13 pp.

Umezaki, I. 1961. The marine blue-green algae of Japan. Mem. Coll. Agr., Kyoto Univ. 83: 1-149.

Weber van Bosse, A. 1923. Liste des algues du Siboga. Seconde partie, Ceramiales, pp. 311-392, pls. 9-10. Siboga Expeditie Monog. 59. E. J. Brill, Leiden.

Yamada, Y. 1941. Notes on Japanese algae IX. Sci. Pap. Inst. Algol. Res., Fac. Sci. Hokkaido Imp. Univ. 2(2): 195-215.

__________. 1944. A list of the marine algae from the atoll of Ant. Sci. Pap. Inst. Algol. Res., Fac. Sci., Hokkaido Univ. 3(1): 1-10.

Yendo, K. 1920. Novae algae Japonicae. Bot. Mag. (Tokyo) 34: 1-12.

ATOLL RESEARCH BULLETIN

No. 121

THE ALGAE OF KAPINGAMARANGI ATOLL, CAROLINE ISLANDS. PART I. CHECKLIST OF THE CYANOPHYTA, CHLOROPHYTA AND PHAEOPHYTA

by Jan Newhouse

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D. C., U. S. A.

March 30, 1969

THE ALGAE OF KAPINGAMARANGI ATOLL, CAROLINE ISLANDS. PART I. CHECKLIST OF THE CYANOPHYTA, CHLOROPHYTA AND PHAEOPHYTA

by Jan Newhouse[1/]

Kapingamarangi, identified with the Carolines although several degrees south of the main group, was the site of the fifth Coral Atoll Expedition[2/] team project of the Pacific Science Board in 1954. Other reports of the work carried out during the ten-week stay on the atoll have been made by Wiens (1956), Niering (1956) and McKee (1956). It is unfortunate that the results of the algal studies have been so long delayed but these are presented now in the belief that this postponement has not detracted from the value of observations and conclusions made at the time of and since the expedition.

In order to obtain an understanding of the algae, four lines of field study were followed.

1. Extent of recognition and use of algae.

Questioning revealed that the people made no direct use of any alga and, although aware of specific differences, there were no names for the various taxa. Aside from recognizing that *Halimeda* segments contributed to lagoon sediments, the people revealed no knowledge or interest in the roles of algae within the atoll area.

2. Biological roles of the algae.

Very limited investigations of these suspected roles could be made during the stay on the atoll. Intertidal beach rock was collected for its blue-green alga content. The distribution of intertidal molluscs, believed to be in part responsible for the decomposition of beach rock, was checked and notes were taken on the repopulation of cleared areas. Collections of these snails were made for stomach contents and these, together with the distributional notes, have revealed clues as to the role of blue-green algae in the decomposition of intertidal beach rock.

It was noted that encrusting coralline algae (*Porolithon* sp.) coated and bound individual coral growths on the seaward reef margins.

1/ Department of General Science, University of Hawaii, Honolulu, Hawaii.

2/ Supported by contract N7onr-29104 (NR 388 001) with the National Academy of Sciences.

3. Studies of marine associations with other team members.

Each member of the field party actively cooperated in several of the team projects and helpful suggestions were freely exchanged on different phases of the summer's work. Particular emphasis was given to the study of selected transects by Dr. Cadet Hand, Dr. Robert Harry, and the writer. A patch reef was mapped with the help of Dr. Harold Wiens, and Dr. William Niering handled the terrestrial organisms on the transects that cut across islets. Biological and geological features were plotted and collections were made of the algae for determination. Supplementary photographs were taken from an aerial platform of three of the transects; a patch reef, a reef flat opposite an islet, and a reef flat extending from seaward to lagoon margins were completely photographed from as nearly a vertical position as practical. Mr. Edwin McKee dredged samples of algae and invertebrates that extended these reef studies into deeper water.

A number of marine associations were recorded and it is expected that these may be characterized in such a way that they will be useful for comparison with other atolls and coral reefs. It was to this end that the greater part of the time on the atoll was devoted.

4. Collection of specimens.

Optical equipment supplied by the Botany Department of the University of Hawaii made possible the examination of fresh algal material as it was collected. The ability to check microscopic characters while in the field was a great aid in the understanding of the transect areas. Use of the equipment also restricted the need for preserving quantities of unknown and, hence, perhaps duplicate material.

There is still considerable effort needed in assembling and interpreting data from these different studies. For this reason, it seems advisable to make available a checklist of those algae already determined and devote another paper to the descriptive and interpretive aspects. All members of the Cyanophyta, Chlorophyta and Phaeophyta have been given final determinations, as have many of the Rhodophyta. These latter will, however, be included in the second paper.

CYANOPHYTA

The names used here are in agreement with the synonomy proposed by Drouet and Daily (1956) and Drouet (1962, 1963 and 1964). Dr. Drouet kindly provided many of the determinations and the collection numbers are those of the author.

Anacystis aeruginosa (Zanard.) Dr. & Daily 1481

Calothrix crustacea Thur. 1186, 1189, 1395, 1484, 1652

Calothrix pilosa Harv. 1655, 1656

Coccochloris stagnina Spreng. 1640

Dichothrix bornetiana Howe 1262

Entophysalis conferta (Kütz.) Dr. & Daily 1254, 1454, 1493, 1499, 1535, 1658

Entophysalis deusta (Menegh.) Dr. & Daily 1185a, 1461a, 1494, 1498b, 1500c, 1636a, 1637, 1643a, 1651, 1652a, 1659

Hormothamnion enteromorphoides Grun. 1167, 1411

Hydrocoleum coccineum Gom. 1012, 1125, 1219, 1367, 1397, 1475a, 1530, 1548, 1663

Hydrocoleum glutinosum (Ag.) Gom. 1241, 1473a

Hydrocoleum lyngbyaceum Kütz. 1133, 1483, 1662

Lyngbya confervoides Ag. 1056, 1075a, 1166, 1320, 1338, 1415, 1438, 1493a, 1496, 1497, 1614

Lyngbya gracilis Rabenh. 1482

Lyngbya lutea (Ag.) Gom. 1320

Lyngbya majuscula (Dillw.) Harv. 1013, 1165, 1177

Lyngbya sordida (Zanard.) Gom. 1014, 1051, 1055, 1078, 1108, 1121, 1162, 1164, 1203, 1222, 1564

Mastigocoleus testarum Lagerh. 1498, 1636, 1643b

Microcoleus chthonoplastes (Mert.) Zanard. 1500a, 1501

Microcoleus tenerrimus Gom. 1473, 1500d, 1656a

Nostoc (commune ?) sp. 1635a

Oscillatoria amphibia Ag. 1644a

Oscillatoria chalybea Mert. 1644

Oscillatoria margaritifera Kütz. 1500b

Phormidium penicellatum Gom. 1116, 1145, 1216, 1329, 1334, 1366, 1515, 1552, 1633, 1660

Porphyrosiphon notarisii (Menegh.) Kütz. 1623

Rivularia polyotis (Ag.) Born. & Flah. 1072, 1345

Schizothrix calcicola (Ag.) Gom. 1081, 1185, 1283, 1461, 1475, 1476, 1489, 1495, 1498a, 1638, 1643, 1652b, 1659a

Schizothrix longiarticulata Gardner 1638b

Scytonema hofmannii Ag. 1130, 1131, 1571, 1634, 1635, 1638a, 1640a, 1641

Scytonema mirabile (Ag.) Born. 1657

Sirocoleum kurzii (Zell.) Gom. 1475b

Spirulina subsalsa Oerst. 1186a, 1287, 1663a

Symploca hydnoides Kütz. 1058, 1079, 1157, 1410, 1488, 1502

CHLOROPHYTA

Dr. Paul Silva and Dr. Edwin Moul provided the _Codium_ and _Halimeda_ determinations respectively. The late Dr. E. Yale Dawson confirmed those of the other taxa.

Acetabularia parvula Solms-Laubach 1382, 1398

Anadyomene wrightii Gray 1117, 1146, 1290, 1553, 1576

Avrainvillea amadelpha Gepp 1027, 1074, 1086, 1109, 1140, 1213, 1289, 1330, 1405, 1509, 1550, 1572, 1583, 1585, 1607, 1649

Boodlea composita (Harvey) Brand 1176, 1464

Boodlea vanbosseae Reinbold 1010, 1011, 1091, 1310, 1335

Bryopsis indica A. & E. S. Gepp 1622

Bryopsis pennata Lamouroux 1270

Bryopsis plumosa (Huds.) Ag. 1426

Caulerpa ambigua Okam. 1214

Caulerpa antoensis Yamada 1000, 1021, 1097, 1132, 1175, 1226, 1268, 1608, 1646

Caulerpa racemosa (Forsskål) J. Ag. 1020, 1044, 1113, 1159, 1173, 1174, 1206, 1249, 1264, 1387, 1599, 1600, 1601

Caulerpa serrulata (Forsskål) J. Ag. 1018, 1096, 1128, 1236, 1250, 1388, 1517

Caulerpa urvilliana Montagne 1001, 1019, 1040, 1136, 1208, 1368, 1459, 1516

Caulerpa verticillata J. Ag. 1385

Cladophora sp. 1279, 1543

Codium arabicum Kütz. 1143

Codium geppii O. C. Schmidt 1017b, 1054, 1269, 1506

Derbesia minima W. van Bosse 1059, 1168, 1419

Dictyosphaeria bokotensis Yamada 1170

Dictyosphaeria cavernosa (Forssk.) Borg. 1043, 1094, 1099, 1456, 1575

Dictyosphaeria mutica Yamada 1325, 1335, 1359

Enteromorpha prolifera (Muller) J. Ag. 1252, 1275, 1300, 1332, 1448, 1486, 1586

Halimeda cylindracea Decaisne 1028, 1034, 1101, 1582

Halimeda discoidea Decaisne 1515a, 1529

Halimeda fragilis Taylor 1030, 1100b, 1102, 1210, 1266, 1296, 1519, 1556, 1579, 1591

Halimeda incrassata (Ellis) Lamouroux 1577, 1602a

Halimeda lacunalis f. lacunalis Taylor 1103, 1422, 1512, 1613

Halimeda lacunalis f. lata (Taylor) Hillis 1022

Halimeda micronesica Yamada 1007, 1023, 1035, 1104, 1225, 1371, 1510, 1521, 1592, 1593

Halimeda opuntia v. hederacea (Barton) Hillis 1017a, 1029, 1237, 1578, 1602, 1645

Halimeda opuntia v. opuntia (L.) Lamouroux 1008, 1015, 1024, 1031, 1041, 1042, 1100a, 1298, 1417, 1518, 1580, 1581, 1603, 1604, 1605

Halimeda stuposa Taylor 1016, 1301, 1400

Halimeda taenicola Taylor 1009, 1036, 1105, 1106, 1107, 1223, 1224, 1297, 1370, 1520, 1570, 1590

Microdictyon okamuri Setchell 1085, 1194, 1263

Microdictyon pseudohapteron A. & E. S. Gepp 1193

Neomeris sp. nov. ? 1161

Neomeris vanbosseae Howe 1006, 1069, 1123, 1255, 1288, 1361, 1598

Protoderma sp. 1440, 1477, 1485

Rhipidophyllon reticulatum (Ask.) Heydr. 1063, 1169, 1184a, 1399

Rhizoclonium hieroglyphicum (J. Ag.) Kütz. 1144, 1424

Siphonocladus rigidus Howe 1120, 1156, 1285, 1562

Ulothrix sp. 1526

Valonia aegagropila Ag. 1075b, 1220, 1350

Valonia utricularis Ag. 1077, 1088, 1197, 1563

Valonia ventricosa J. Ag. 1087, 1114, 1391, 1514

PHAEOPHYTA

Dictyota friabilis Setchell 1014a, 1239, 1276, 1389, 1433, 1455, 1629

Dictyota patens J. Ag. 1066, 1541

Ectocarpus indicus Sonder 1436

Ectocarpus mitchellae Harvey 1630

Padina commersonii Bory 1014b, 1057, 1112, 1129, 1160, 1240, 1423

Pocockiella variegata (Lamouroux) Papenfuss 1005, 1060, 1067, 1070, 1141, 1155, 1163, 1191, 1221, 1242, 1247, 1256, 1267, 1351, 1416, 1427, 1431, 1450, 1528, 1545

Sphacelaria novae-hollandiae Sonder 1429, 1437, 1449, 1503

Turbinaria ornata (Turn.) J. Ag. 1083, 1142, 1620, 1648

LITERATURE CITED

Drouet, F. Gomont's ecophenes of the blue-green alga, *Microcoleus vaginatus* (Oscillatoriaceae). Proc. Acad. Nat. Sci. Philadelphia 114: 191-205, 1962.

Drouet, F. Ecophenes of *Schizothrix calcicola* (Oscillatoriaceae). Proc. Acad. Nat. Sci. Philadelphia 115: 261-281, 1963.

Drouet, F. Ecophenes of *Microcoleus chthonoplastes*. Revue Alg. 7: 315-324, 1964.

Drouet, F. and W. A. Daily. Revision of the coccoid Myxophyceae. Butler Univ. Bot. Studies Vol. 12: 1-218, 1956.

McKee, E. D. Geology of Kapingamarangi Atoll, Caroline Islands. Atoll Res. Bull. 50: 1-38, 1956.

Moul, E. T. New records of *Halimeda* and *Udotea* for the Pacific area. Atoll Res. Bull. 106: 1-10, 1964.

Niering, W. A. Bioecology of Kapingamarangi Atoll, Caroline Islands: Terrestrial Aspects. Atoll Res. Bull. 49: 1-32. Fig. 1-33, 1956.

Wiens, H. J. The geography of Kapingamarangi Atoll in the Eastern Carolines. Atoll Res. Bull. 48: 1-93, 1956.

337-682 O-69—3

ATOLL RESEARCH BULLETIN

No. 122

MARINE TOXINS FROM THE PACIFIC II.
THE CONTAMINATION OF WAKE ISLAND LAGOON

by Albert H. Banner, Judd C. Nevenzel and Webster R. Hudgins

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D. C., U. S. A.

March 30, 1969

MARINE TOXINS FROM THE PACIFIC II. THE CONTAMINATION OF WAKE ISLAND LAGOON [1]

by Albert H. Banner, Judd C. Nevenzel and Webster R. Hudgins[2]

Wake Island lies at 19° 18' N and 166° 38' E; it is a small atoll about 6.5 km long and 3 km wide. Its shallow lagoon, with a maximum depth of 25 m, has no connection with the surrounding sea at low water, but at high tide water may enter and leave the lagoon either across the two-mile broad western reef or through a passage on the northern side between Wake Island proper and Peale Island (the original passage between Wake and Wilkes Islands on the southwestern side has been blocked by a causeway). The island is inhabited by about 1500 people who are primarily employed in the servicing of trans-Pacific aircraft.

Observations

The evening of Sunday, 20 June 1965 was unusually still with a complete cessation of the normal trade winds. Police Officer Earl Harris, on night duty, noticed an unusual, pungent and repulsive odor about midnight, when he was passing over the bridge connecting Wake and Peale Islands. The odor was so strong that he paused and flashed his spotlight into the water below. He was surprised to find that water rushing into the lagoon with a rising tide, instead of being clear as normal, was milky in appearance. At 3 A. M. and again at 6 A. M. he again checked the water, which remained pungent and milky.

1/ Contribution No. 305, Hawaii Institute of Marine Biology, University of Hawaii, Honolulu, Hawaii 96822. The second in a continuing series of papers on marine toxins published by a group at the Hawaii Institute of Marine Biology, University of Hawaii; the first 'Advances in the Investigation of Fish Toxins' by Albert H. Banner in Animal Toxins, 1967, eds. Russell, F. E., and P. R. Saunders, xiii + 428, Pergamon Press, Oxford.

2/ A. H. Banner, Department of Zoology, University of Hawaii; J. C. Nevenzel, Department of Biophysics and Nuclear Medicine, University of California, Los Angeles; W. R. Hudgins, Research Laboratory, Allied Chemical Corporation. A. H. Banner responsible for gathering field data and biological observations; W. R. Hudgins for general chemistry; J. C. Nevenzel for detailed chromatographic analyses. Work at Hawaii Institute of Marine Biology supported in part by U. S. Public Health Service Grant EF-00216 and Office of Naval Research Contract Nonr 2289(00), NR 107-405; work at University of California, Los Angeles, by the Atomic Energy Commission Contract AT(04-1) GEN-12 between the Commission and the University.

At 8 o'clock that morning he visited the beach at Peale Island with the Assistant Island Manager, Mr. George La Caille, and the resident physician, Dr. Frederick Goff. They found a band of floating material, perhaps a meter wide and of the consistency of a thin soup, reaching along the lagoon beach of Peale Island as far as the eye could see. Patches of the material were floating far out into the lagoon. The material was light in color with tinges of pink. Most characteristic of the material was its sweet but fetid odor, variously described as "sickeningly sweet," "a combination of a molasses refinery and an exposed oyster flat," or "like sewage." During that day and for several days to come the odor permeated the whole island.

By early afternoon of that day fish were observed to exhibit aberrant behavior. As the material, now being moved from the lagoon towards Peale Island by a slight westerly wind, drifted towards the shore, the small lagoon fish behaved frantically -- moray eels left their holes and swam to deeper water, while others such as wrasses leaped from the water to the beach and lay there flopping in the sand. The smell, the action of the fish, and especially the unknown nature of the flotsam, caused the officials to ban all swimming, boating, and fishing in the atoll waters.

During the next several days the contamination of the lagoon was watched carefully by Dr. Frederick Goff. The original milky material turned pink, and in concentrations along the shoreline, brownish red. So many fish were killed that a sanitary patrol was sent out; it gathered over three barrels of dead fish from the shore of Peale Island. The receding tide left the exposed rocks and bars of the lagoon stained red. Even the birds were afflicted and a number of sooty terns in the colony on Peale Island which were feeding in the western section of the lagoon sickened and died. A frigate bird was seen to dive into a floating mass, presumably after a sick fish; but when it surfaced it was unable to fly and flopped its way to a small sand bar. Within minutes it collapsed and died.

Over four liters of the material were dispatched frozen to the Hawaii Institute of Marine Biology for study; it was received on the afternoon of 24 June (Wake time). Arrangements were completed for the senior author to visit the island as a consultant.

Late in the afternoon of 26 June and the following day, the senior author was able to inspect contaminated beaches and the surrounding waters. No longer was there any floating material in the water -- it was reported to have disappeared by 23 or 24 June. However, near the high tide zone on the beaches at Peale Island were patches of reddish-brown creamy to waxy material. No patches were excessively large, although some were up to a meter wide and seven or more meters long, and with a thickness of a millimeter or so. Other patches were more concentrated, over a centimeter thick for a diameter of more than 30 centimeters. On the lagoon side of Peale Island the patches were most common, but they were also found on the ocean side near the passage as well and correspondingly near both sides of the passage on Wake Island. On Wilkes Island, across the lagoon, a few patches were found. On sandy beaches the material had penetrated into the sand so that when

the top layer was disturbed, the underlying sand had a pink cast. The exposed sand in these areas was of light grey color rather than its characteristic white. Similarly, tufts of attached algae on a shallow tide flat at Peale Island were coated with the pink material. The waxy material on the beach, the sand, and the algae all had the pungent, sickening but sweet, odor.

Along the shores of Wilkes Island were numerous dead fish that obviously had been exposed for some time. One sick tern, unable to fly, was collected on Peale Island on Saturday evening; during the night it died.

On the morning of 27 June the lagoon was inspected by boat and the lagoon and the surrounding waters of the island by air from a U. S. Navy amphibian plane flying at 150 meters. No floating matter was seen, and the coral heads of the western side of the lagoon, exposed by the extreme low water at the time of inspection, seemed unaffected.

At the recommendation of the senior author the lagoon was opened to swimming and boating on Sunday. Bathers reported the water "had a bad taste" but no ill effects were seen from swimming.

Laboratory Examination

The frozen material shipped to Honolulu was pink with grey traces. It was a consistency of thick ladled or skimmed cream, with some free water on the bottom of the container. The waxy material collected from the beaches on the 26th and 27th had a consistency of a thick medicinal ointment. Both would adhere to the skin when touched.

Microscopically, the bulk of both materials was without formed structures and was immiscible with water when squashed on a microscope slide. In all material examined there were numerous oil droplets and an amorphous ground substance. The pink masses were equally formless and were scattered as small units through the other material. In the water surrounding the sample shipped to the laboratory were numerous green, spherical cells of a unicellular alga; in the tufts of contaminated algae collected from Peale Island, the cells of the filaments appeared alive; in this material and in the contaminated sand were numerous ciliate protozoans. However, in the consolidated masses of the waxy cream from the beaches there was no life.

The creamy material delivered to the Hawaii Institute of Marine Biology was found, by dehydration at 45° C under reduced pressure, to contain 68.8 per cent water and volatile components, 31.2 per cent solids which obviously included the salts left by the evaporated sea water (estimated at perhaps 2 per cent of the weight of the original sample, a flame test for sodium was positive).

Five hundred grams of the same emulsion, undehydrated, was extracted by occasional shaking for one day in equal volume of 95 per cent ethanol and filtered; the evaporated ethanolic extract yielded 15.3 g of a bright yellow waxy solid. A dry ice trap, followed an ice trap, in the distillation line yielded a small amount of a colorless

volatile liquid with an odor characteristic, in part, of that of the original sample. The residue from the ethanolic extraction was in turn extracted with 500 ml of diethyl ether, and yielded 35 g of a brilliant orange waxy solid that melted slightly below 45° C and that contained scattered microcrystals. It was possible to dissolve and recrystallize the crystals in ethanol; they were white and plate-like, and had a sharp melting point at 51° C. The residue undissolved by the diethyl ether extraction was yellow and fibrous; it gave a positive biuret test for protein.

The toxicity of the mixture and some of its principal components were checked to see if the observed deaths of fish and birds could be attributed to the mixture. The crude cream was emulsified and stirred into an aquarium at about 10 ml per liter and three butterflyfish (*Chaetodon* sp.) were added; the aquarium was continuously aerated. In 40 to 60 minutes the fish, after showing marked respiratory distress, died. Five white mice, weighing from 21 to 24 g, were force-fed some 0.3 to 0.6 ml of emulsified mixture; all exhibited heavy breathing, gasping and listlessness, and three died overnight. Similarly, when the supernatant wax from the original sample was force-fed to mice in similar amounts, three of the six mice died overnight. However, when the ethanolic or ethereal extracts were injected intraperitoneally into mice at the rather massive dosage of 4 mg/g, no deaths resulted. The final fibrous residue caused no deaths when force-fed, but the same residue when injected at 4 mg/g caused one of the two mice to die overnight.

A stoppered vial of the soft beach material with a pink cast was kept at room temperature; after four days it smelled strongly of hydrogen sulfide.

Analysis of the Lipid

The total lipid in the original creamy material delivered to the Hawaii Institute of Marine Biology was obtained by extraction into diethyl ether, using centrifugation and methanol to break emulsions. The crude lipid was separated by adsorption column chromatography on silicic acid (Fillerup and Mead, 1953) into the fractions listed in Table I. The identification of the main constituent (60%) of the Wake Island lipid as wax esters (that is, fatty acids esterified with long-chain alcohols) was confirmed by (a) direct comparison in thin-layer chromatography (TLC) with synthetic heptadecyl stearate; (b) gas-liquid chromatography (GLC) of the unhydrolyzed esters (*cf.* Nevenzel, *et al.*, 1966) -- the results are given in Table II; and (c) hydrolysis to acid and alcohol moieties, which were analyzed by GLC -- the acids as their methyl and phenacyl esters and the alcohols as their trifluoroacetate derivatives (Nevenzel, *et al.*, 1965) -- see Table III.

A comparison of the analysis of the Wake Island lipid with the data of Lederer, *et al.*, 1946, for ambergris (also given in Table I) makes it clear that our material was not ambergris. A direct comparison by TLC of the crude Wake Island lipid with authentic low-grade ambergris from Hawaii further emphasized this point: on Bio-Sil A (Bio-Rad Laboratories, Richmond, California) developed with 10 per cent diisopropyl ether in petroleum ether (b.p. 60-70° C) the Wake Island lipid

showed one main spot of R_f 0.68 (identical to authentic wax esters) and a faint spot of R_f 0.07 while the Hawaiian ambergris had only a faint spot at R_f 0.69 for wax ester or sterol ester, another minor component of R_f 0.31, and the main spot of R_f 0.25 with extensive tailing; authentic octadecanol had an R_f of 0.13 and cholesterol about 0.05 in this system.

The sterol-containing fraction of Table I was further characterized by TLC, which confirmed the presence of free long-chain alcohols or cholesterol. By GLC analysis of the trifluoroacetate derivatives of these hydroxyl-containing compounds straight chain alcohols C_{16}-C_{25} were identified together with a trace of a higher molecular weight compound, thought to be a triterpene alcohol or a sterol other than cholesterol. TLC examination of the most polar lipid fraction established the presence of traces of free fatty acids and phospholipid (probably lecithin), but the bulk of the material appeared as a streak with no defined spots and was not characterized further. The yellow color of this sample was due to strong end absorption from a peak below 230 mu; no identifiable pigment was present.

Discussion

To our knowledge, no bloom of an alga, either fixed or planktonic, nor any spawning or other activity of a marine invertebrate or fish has been reported to form an amorphous mass of floating lipids of such volume and nature. Aside from the results of man's activity, the only massive depositions of waxy material in the sea is the voided secretion of the gut of the sperm whale, known commercially as ambergris. As Wake Island lies in the traditional whaling ground for the sperm whale, it was originally thought that the contaminant of the lagoon was a huge mass of ambergris, emulsified and altered in consistency in its passage through the surf. The hypothesis was rendered even more attractive by the musty smell noted on the contaminated beaches.

However, the laboratory studies of one of us (Nevenzel) have destroyed the hypothesis of the other two: the material definitely is not ambergris. On the other hand, only lipids of the sperm whales (family _Physeteridae_, Hilditch and Williams, 1965), the beaked whales (family _Ziphiidae_, Mori, _et al._, 1964), and some pelagic copepods (Nevenzel, unpublished) and fishes (families _Myctophidae_, Nevenzel and Rodegker, 1965; _Gadidae_, Komori and Agawa, 1955; _Gempylidae_, 1963; and _Trachichthyidae_, Kaufmann and Gottschalk, 1956), and the living fossil (family _Latimeridae_, Nevenzel, _et al._, 1966) are largely wax esters. Of seven species whose wax esters have been examined in detail, only those of the sperm whale have as low an average chain length as those observed here: Wake Island lipid has 85 per cent esters shorter than C_{34}, spermaceti wax 90 per cent, but the wax esters from fish have only 4-20 per cent of the total shorter than C_{34}. The available data on the composition of several sperm whale lipids are given in the Tables for comparison with the corresponding values for the Wake Island lipid. Note that spermaceti is the material which crystallizes from the total sperm whale oil on chilling and consists of the more saturated, longer chain wax esters; it contains only traces of triglycerides or unsaturated components.

The simplest explanation for the origin of the Wake Island material is that a mass of whale oil with some fibrous content floated into the lagoon in an emulsified condition, where it settled out into the floating cream-like layer. In the process it was acted upon by micro-organisms and was subjected to chemical changes (hydrolysis, recombination, oxidation, etc.). In general, the differences in composition between the Wake Island lipid and sperm whale oil (Tables I and III) are consistent with (a) proportionally greater losses of the shorter chain wax esters, due to their greater solubility and greater rate of hydrolysis; (b) the extensive losses of unsaturated components by autoxidation; and (c) the preferential loss of triglycerides because of their higher content of unsaturated fatty acids and greater rate of hydrolysis. The net result of these processes would be the production of a lipid consisting largely of saturated wax esters with a reduced content of C_{26} and C_{28} components: *i.e.*, something approaching spermaceti. Tables II and III confirm the similarities of Wake Island lipid with spermaceti, although in the former the content of decanoic acid (10:0) is ten times as much as expected for whale oil, and the percentage of palmitic acid (16:0) is also too high. Nor does this explanation account for the toxicity of the samples.

The toxicity probably is the result of bacterial action upon the mixture. When the material was first seen, it was emulsified into a thin milky suspension. In such a state the surface area for bacterial attack would have been tremendous and as the fatty material reconsolidated in the "cream" found floating on the surface, the bacteria were also incorporated. Some probably worked on the lipids, but others could have worked upon the fibrous protein mixed in the mass. By-products from the bacterial decomposition of the mixture could be toxic and account for the death of fish and possibly the birds. An example of such a product is the hydrogen sulfide noted both in the field and the laboratory. The exhaustion of oxygen in the water by bacterial action under the floating "cream" could also account for some deaths of fish, but it cannot account for the death of the butterflyfish in the well-aerated aquarium. The inability of the birds to fly probably was not from the toxicity of the mass but from the oils coating their feathers.

It is more difficult to account for the observed large amount (17.5%) of decanoic acid (C_{10}), since in sperm whale oil C_{10} is a minor constituent; *cf*. Table III. One possible suggestion is that the mass reforming from the thin emulsion trapped and incorporated C_{10} acids from a bloom of blue-green alga, for *Oscillatoria* (*Trichodesmium*) *erythraeum* is known to contain these (Parker, and Van Baalen, personal communication). However, from interviews of the residents, there was no indication of a previous bloom of alga in the lagoon, and the coincidence of a major bloom of blue-green phytoplankton, a rather rare occurrence, at the moment of the contamination of the lagoon by waxes strains one's credulity.

Conclusions

As sperm whales do not give up their wax esters voluntarily (unlike their ambrein and sterols) we find the best way[3/] to account for the contamination of Wake Island lagoon is to postulate that some unknown whale factory ship, cruising the whaling grounds discharged its rendering retorts for unknown reasons. This crude oil-wax concentrate, still containing the fibers of the adipose tissue, floated in a coherent mass and probably for a relatively short time, until it was carried by currents to the reef off the northern coast of Wake Island. It arrived in time for the currents of the incoming tide at the shallow entrance to the lagoon. Here the currents carried it through the surf (in spite of the calmness of the night, there would be continuing and possibly heavy surf on the windward reef face). Once the crude mixture was emulsified by the surf, the great surface area permitted rapid bacterial action on all components, speeding a massive alteration of the lipids and decomposing the proteins. A chemical by-product by this action could be the loss of some lipid fractions, thereby concentrating other fractions (such as cetyl alcohol), and the synthesis of C_{10} acid. The red cast to the mass observed in the water and on the beaches probably was the result of growth of pigmented sulfur bacteria, which were utilizing the H_2S given off in other bacterial decomposition.

We further postulate that toxic by-products of the bacterial action killed the fish and rendered the mixture toxic to laboratory mice when fed or injected with it. At the same time, the presence of bacteria caused the ciliate protozoans, which feed on bacteria, to increase and the bacterial release of nutrient salts encouraged the growth of unicellular algae. Possibly some C_{10} acids were incorporated into the mass from the phytoplankton. Otherwise we cannot account for their presence.

Finally, the emulsified droplets, floating to the surface, reformed into the waxy mass and was carried to the beaches by the light airs.

3/ The senior author alone, having his ambergris hypothesis ruthlessly destroyed by fact, wishes to emphasize that the chromatography proved that this particular combination of wax esters could have come from no known animal or plant. He suggests that we must therefore look for some yet unknown animal, and that perhaps the Great Sea-Serpent, so convincingly described by Oudemans, might be a wax ester producer. Presumably even the sea-serpent does not shed its adipose tissues, but perhaps the magnificent creature might discharge wax ester as a medium for its _aura seminalis_. He begs to recall the described _aura_ of the Wake Island lagoon.

Acknowledgements

We wish to thank the Federal Aeronautics Administration and its acting Regional Flight Surgeon, Dr. P. M. Corboy, for the samples and the opportunity to visit Wake Island; Dr. Frederick Goff and Police Officer Earl Harris for their aid and information on the early conditions there on Wake Island; and Miss Betty Jane Stephens for running laboratory tests at the Hawaii Institute of Marine Biology.

BIBLIOGRAPHY

Fillerup, D. L., and J. F. Mead. 1953. Chromatographic Separation of the Plasma Lipids. Proc Soc. Exptl. Biol. Med., 83, 574-77.

Hilditch, T. P., and P. N. Williams. 1965. THE CHEMICAL CONSTITUTION OF NATURAL FATS. 4th ed. New York, Wiley, pp. 72-74.

Kaufmann, H. P., and E. Gottschalk. 1956. The Body Oil of the Fish *Hoplostethus islandicus*, II. Fette, Seifen, Anstrichmittel, 58, 411-16.

Komori, S., and T. Agawa. 1955. Oil of *Laemonema morosum*. I. Research on the Docosenol Fraction. J. Am. Oil Chemists' Soc., 32, 525-28.

Lederer, E., R. Marx, D. Mercier, and G. Perot. 1946. Sur les constituants de l'ambre gris II. Ambreine et Coprostanone. Helv. Chim. Acta, 29, 1354-65.

Mori, M., Y. Iwakiri, A. Ozawa, and S. Shibata. 1964. Analysis of Fatty Acid and Fatty Alcohol Compositions of Sperm Whale Oil by Gas-liquid Chromatography. Nippon Suisan Gakkaishi, 30, 161-69.

Nevenzel, J. C. 1963. The Wax Esters of *Lepidocybium flavo-brunneum*. USAEC report UCLA-520, p. 22.

__________, and W. Rodegker. 1965. The Lipids of Midwater Marine Fishes. USAEC report UCLA-12-576, pp. 23-25.

__________, W. Rodegker, and J. F. Mead. 1965. The Lipids of *Ruvettus pretiosus* Muscle and Liver. Biochemistry, 4, 1589-94.

__________, W. Rodegker, J. F. Mead, and M. S. Gordon. 1966. Lipids of the Living Coelacanth, *Latimeria chalumnae*. Science, 152, 1753-55.

Oudemans, A. C. 1892. THE GREAT SEA-SERPENT. Leiden, E. J. Brill. xv+592.

Parker, P. L. 1966. Institute of Marine Science, University of Texas, Port Aransas, Texas. Personal communication, reporting on work done with Dr. C. Van Baalen.

Tateishi, T., M. Fujiwara, and H. Sakurai. 1958. Separation of Sperm Whale Head Oil into Wax and Glycerides by Elution Chromatography. Kogyo Kagaku Zasshi, 61, 1580-82.

TABLE I

Composition of Wake Island Lipid (Weight %)

Component lipids	Wake Island lipid	Ambergris (1)	Sperm Whale Head Oil (2)
Hydrocarbons	-	3 ± 1	-
Ketones	-	7 ± 1	-
Wax esters	59.9	6 ± 2 (wax esters and triglycerides combined)	72.7
Triglycerides	9.5		24.6
Free sterols and alcohols	6.3	78 ± 17	-
Free fatty acids and polar lipids	24.3	5	2.0

(1) Normalized data of Lederer, et al., 1946.

(2) Tateishi, et al., 1958.

TABLE II

Composition of Wax Esters of Wake Island Lipid (Weight %)

Source	Wake Island Lipid	Spermaceti (1)
Homologue (2)		
26:0	10.7	0.6
27:0	-	0.2
28:0	0.8	14.8
29:0	-	1.8
30:0	11.0	36.1
30:1	0.7	-
31:0	-	3.0
32:0	58.2	31.8
32:1	3.7	-
33:0	-	1.8
34:0	4.3	8.2
34:1	8.4	-
36:0	-	1.8
36:1	2.2	-

(1) "Spermaceti, U.S.P.", Fisher Scientific Company, Fair Lawn, N.J.

(2) The number before the colon indicates the total number of carbon atoms, the number following the colon denotes the total number of double bonds in the molecules.

TABLE III

Component Fatty Acids and Alcohols of Wake Island Wax Esters (Weight %)

Source	Wake Island Lipid		Spermaceti (1)		Sperm Whale Head Oil	
	Acids	Alcohols	Acids	Alcohols	Acids (2)	Alcohols (3)
Homologues (4)						
10:0	17.5	-	trace	-	1.0	-
12:0	0.2	trace	14	-	11.4	-
12:1	-	-	-	-	4.2	-
14:0	9.3	0.8	39	2.7	17.0	7.7
14:1	-	-	-	-	11.8	-
15:0	0.2	0.1	1.2	1.2	-	0.9
16:0	60.8	88.0	38	80.0	9.8	44.9
16:1	4.1	0.8	trace	-	16.0	5.3
16:2	-	-	-	-	-	1.2
17:0	-	-	1.0	1.8	-	-
18:0	1.0	7.1	5.6	12.9	1.7	3.0
18:1	5.0	1.0	trace	-	17.8	33.4
18:2	0.1	-	-	-	2.0	0.6
20:0	0.1	1.0	trace	0.4	0.6	-
20:1	0.8	0.6	-	-	5.8	1.8

(1) "Spermaceti, U.S.P.", Fisher Scientific Company, Fair Lawn, N.J.

(2) Data of Tateishi, et al., 1958, recalculated to estimate value for 18:2.

(3) Data of Mori, et al., 1964, for Arctic Sperm Whale, head oil.

(4) The number before the colon indicates the number of carbon atoms, that following the number of double bonds in the acid or alcohol.

Figure 1. Intertidal area at Peale Island, showing contamination of beach. The normal beach color is dazzling white, as shown in the fore- and background; the crescentic darkened area, reddish-brown in hue, is of the waxy material well over a meter wide but only a few millimeters thick.

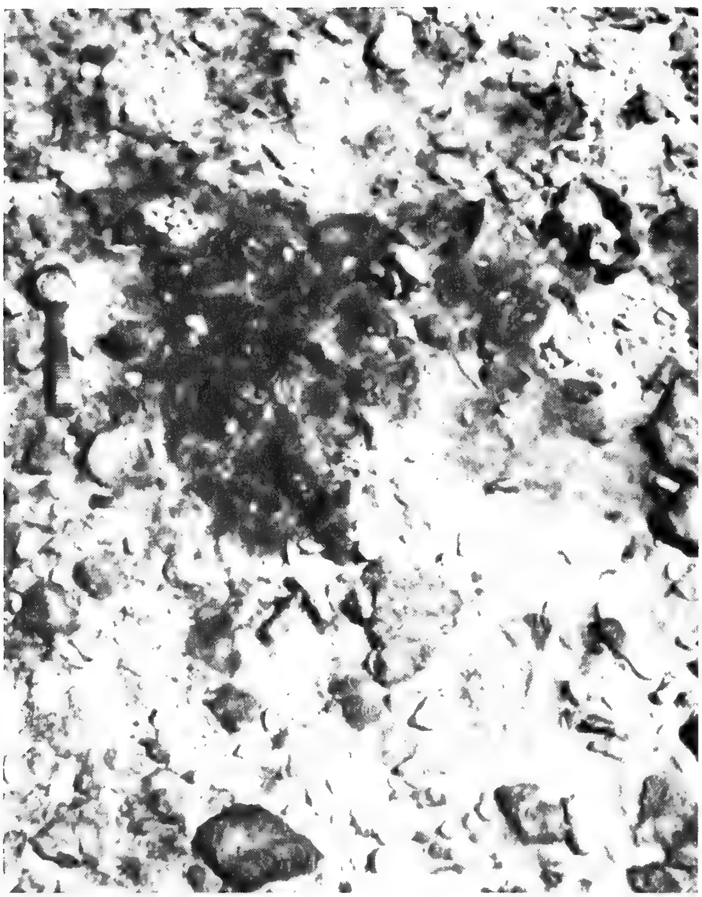


Figure 2. Intertidal area at Peale Island, showing a "glob" of contaminant. The thick material, dark red-brown in color, is of the consistency of a thick ointment and covers the shells and coral fragments on the beach variously from 1 to 4 cm thick. The scale may be interpreted from the wrist watch on the upper left.

ATOLL RESEARCH BULLETIN

No. 123

WAKE ISLAND VEGETATION AND FLORA, 1961-1963

by F. R. Fosberg and M.-H. Sachet

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D. C., U. S. A.

March 30, 1969

337-682 O-69—4

WAKE ISLAND VEGETATION AND FLORA, 1961-1963

by F. R. Fosberg and M.-H. Sachet

In 1959 we summarized observations on the vegetation and flora made on four short visits to Wake Island in 1951, 1952 and 1953, along with what was already known (Atoll Research Bulletin 67, 1959). Particular attention was given to the effects on the vegetation of the typhoon of September 16, 1952. A list of the vascular flora with citations of specimens, brief characterizations of species, and notes on occurrence was a principal part of that paper.

In September 1961 M.-H. Sachet spent a week on the island making observations on the vegetation, flora and general ecology through the courtesy of Dr. Bruce Halstead. In March 1963, sponsored by the Pacific Science Board and the Office of Naval Research, M.-H. Sachet and F. R. Fosberg visited the island with R. H. Alexander for four days, observing changes in the vegetation and looking for traces of the effects of the 1952 typhoon, which had been the object of a special study by Fosberg in 1953 (ARB 67, 1959). A few plants were collected on each of these visits. Observations made on these trips are belatedly offered here, with notes on the changes from ten years earlier. A few records have been added from collections made by Mr. R. W. McFarlane, who made several visits to Wake in 1963-1965 under the auspices of the Pacific Ocean Biological Survey Program, also one or two by older collectors. The scope of this paper is the same as that of the 1959 one. Observations made on other aspects of the island will be put on record in another paper. Notes on the birds were included in ARB 114, 1966.

Effects of 1952 Typhoon

The only thing worth commenting on under this heading is the almost complete lack of any noticeable remaining effects. An occasional dead *Tournefortia* tree or dead branch on one with bark abraded off may still be seen in some areas of scrub forest. Also many of the areas most damaged by the typhoon are now cleared and occupied by installations. However, the general lack of obvious typhoon effects after ten years is in line with the principle that vegetation of a pioneer character, such as that on dry atolls, recovers its original appearance and composition very rapidly after damage. It also supports the idea that most atoll plant species have evolved means of ready and quick recovery from the effects of typhoons, over the millenia that they have been exposed to these severe storms.

Vegetation

In general the land surface of the island has been almost completely disturbed. In all probability no original vegetation remains, except possibly some *Sesuvium* flats and *Pemphis* scrub along the lagoon margins.

The fact that almost the entire indigenous and spontaneous flora of the island is of an extreme pioneer character causes the secondary vegetation to look rather natural and at least some of the original vegetation types to recur after disturbance.

Of these, a scrub forest of Tournefortia, with or without scattered Cordia and Pisonia, was in 1963 the most prevalent. Its stature varied from 2 to about 6 m and spacing from closed to open. This had little undergrowth where closed, but with the branches very low and spreading and those of adjacent trees usually tangled together. Where it was open there was an abundant herbaceous to scrubby growth of many species, especially Sida fallax, Heliotropium anomalum, Pluchea odorata, Lepturus spp., and Boerhavia spp. Portulaca lutea was common locally, even occurring in closed forest, but not in very vigorous condition. Occasional dead branches of larger Tournefortia trees, and even a few whole dead trees, recognizable by lack of bark on trunks and larger branches, persisted from the 1952 typhoon, but these did not change materially the aspect of the vegetation.

Judging by the stand of Tournefortia seedlings on the cleared area at the west end of Peale Islet, this type may, under some conditions, re-establish itself immediately after disturbance, without any intervening successional stages. Where it does not, as around installations, the difference may possibly be due to compaction, or perhaps to competition with such aggressive pioneers as Pluchea, and even Cenchrus, Eragrostis or other herbs.

Pisonia forest, with or without an admixture of Cordia, was formerly the most stable and mesophytic vegetation type on the island. The only good area of this remaining in 1953 (also seen in 1961) has been completely destroyed recently by overzealous use of the bulldozer, leaving only bare ground. In a few nearby areas clumps of fair sized Pisonia and Cordia trees remained and, if these could be left undisturbed, the Pisonia forest so characteristic of coral islands might re-establish itself over a long period of years. That this will be permitted to happen seems improbable, however.

Small areas of Cordia scrub near Peacock Point, observed in 1952 had increased in stature somewhat, but were greatly reduced in area.

Pemphis scrub still lined portions of the lagoon shore but the area had been greatly reduced since 1953 by clearing. Some of the Pemphis bushes had increased in stature to several meters but were not at all comparable to certain patches of Pemphis forest seen in 1952. Except for the Tournefortia scrub forest, Pemphis scrub was the most prevalent reasonably natural vegetation type remaining on Wake.

A widespread vegetation complex on drier atolls in the central Pacific is a scrub of Sida fallax with, normally, a strong admixture of Lepturus and, where it is a member of the flora, Heliotropium anomalum. This was alluded to but not emphasized or described on Wake by Bryan in 1923 (Christophersen 1931) and not noticed at all by Fosberg in 1951-1953 (Fosberg 1959). However, two variants of this complex in 1963 occupied small areas. On the cleared area at Kuku

Point, on the west end of Wilkes Islet, and in the openings in Tournefortia forest nearby, Sida, or Sida and Heliotropium formed an open to closed very low scrub, with abundant Lepturus, Portulaca lutea, and Boerhavia where the bushes did not form a closed cover. This was doubtless present locally in openings before the clearing which was done prior to 1961.

This scrub, in much of the cleared area back of Kuku Point, gave way to herbaceous vegetation, locally, in patches dominated by Portulaca, Boerhavia, Lepturus, and in one area, Lepidium. The whole formed a mosaic that seems more or less random in its pattern.

Just west of Peacock Point, back of the south coast of Wake Islet, were openings and thin places in the Tournefortia scrub and scrub forest occupied by an open to closed dwarf scrub of Heliotropium anomalum. This may simply have been missed during earlier visits or it may have developed in cleared spots resulting from the 1952 typhoon. This area was not visited in 1953.

Sesuvium flats in 1963 occupied perhaps more area than a decade before, being still present on wet muddy or sandy lagoon margins, also coming in where excavation had reached the water table, as in the brackish pond in the triangle surrounded by runways and taxi-strips opposite the terminal building. The plants formed a succulent bright green mat in low wet places, but were more scattered on exposed beach ridge areas on other parts of the atoll.

Roadsides and other recently cleared areas were mostly covered by a vegetation of annual grasses and other herbs, especially Cenchrus echinatus, Eragrostis tenella, Dactyloctenium aegyptium, Eleusine indica, and several Euphorbia species. Such areas, if left without further disturbance for awhile, might change to an open or closed scrub of Pluchea odorata. Where traffic is heavy there persisted a sparse "lawn" of dwarfed plants of Dactyloctenium, Eleusine, Fimbristylis and other herbs.

Before the 1963 visit the weather had been sufficiently dry that much of the herbaceous weedy vegetation was practically dried up, though by no means as much so as in May 1952. Many leaves had recently fallen from the Tournefortia, but not so many as to give a dry aspect. The leaves of Cordia and Pisonia were predominantly still green. A few of the Pisonia bushes were coming into flower. Fruits and a few flowers were seen on Cordia.

Evidences of a recent storm, or, at least, of very high waves, were seen on both north and south coasts in the form of large areas of pale gray to white, presumably recently uncovered beachrock, white stirred up gravel, and dead shrubs at the top of the beach and just back of it. The Air Force officers present said that the period of high waves was in October 1962.

VASCULAR FLORA[1/]

The list that follows includes all the species from the 1959 list, with remarks on any change of status from that observed in 1951-1953, as well as 27 species newly recorded here. Of the latter 5 are cultivated in pots, 7 cultivated in gardens, 14 are spontaneous but introduced, and only one, _Tribulus cistoides_ probably indigenous. As in the 1959 list, introduced species are marked by an asterisk. Species here recorded for the first time from Wake are indicated by an exclamation point. A few name changes are recorded and misidentifications corrected. In these cases the name used in the 1959 list is given as a synonym.

The location indicated as the IAS compound is on the site of the old TAL compound on the southwest arm of Wake Islet about 300 m east of the channel. The Japanese monument is on the north angle of Wake Islet a short distance in from the north bay of the lagoon. Flipper Point is the south peninsula of Peale Islet. Kuku Point is the west point of Wilkes Islet. The FAA Dock is at the west end of the southwest arm of Wake Islet.

PANDANACEAE

*PANDANUS TECTORIUS Park.
Same tree seen in 1961 and 1963, much larger than in 1952.

GRAMINEAE

*CENCHRUS BROWNII R. & S.
One plant seen at Japanese monument 1963, _Fosberg 43522_.

*CENCHRUS ECHINATUS L.
Generally distributed in open disturbed areas, _Sachet 898_.

*CHLORIS INFLATA Link
Still common in disturbed areas 1961, _Sachet 895_, also seen in 1963.

*CYNODON DACTYLON (L.) Pers.
Seen in IAS area 1961, _Sachet 873_, one sizeable patch on Peale Islet 1963.

*DACTYLOCTENIUM AEGYPTIUM (L.) Reich.
One of the commonest plants in disturbed areas, 1963.

*DIGITARIA CILIARIS (Retz.) Koel.
Not seen in 1961, 1963.

[1/] Specimens cited are deposited in the U. S. National Herbarium, except as otherwise indicated.

*DIGITARIA GAUDICHAUDII (Kunth) Hens.
Not seen in 1961, 1963.

*DIGITARIA INSULARIS (L.) Henr.
Common around old Japanese garden site 1961, Sachet 894, also seen 1963.

*ELEUSINE INDICA (L.) Gaertn.
Collected near old Japanese garden in 1961, Sachet 899. Common in disturbed places and persisting around former disturbance, 1963; near Terminal Area, Fosberg 43515.

*ERAGROSTIS TENELLA (L.) Beauv.
E. amabilis (L.) W. & A.
Generally distributed and abundant in open places, Sachet 872.

*ERAGROSTIS POAEOIDES Beauv. ex R. & S.
Not seen 1961, 1963.

LEPTURUS GASPARRICENSIS Fosb.
Collected in IAS area 1961, Sachet 865, 1963, abundant generally on Wilkes, Fosberg 43533, and Peale, Fosberg 43512, but rare on Wake Islet.

LEPTURUS REPENS var. SEPTENTRIONALIS Fosb.
Common generally Fosberg 43535, 43540, 43541, 43513; Sachet 867, 888.

LEPTURUS -- putative hybrids between L. gasparricensis and L. repens var. septentrionalis (see Fosberg, Phytologia 15: 496-498, 1968). Local on Peale Islet: near bridge, in depressions, Fosberg 43510, s.e. tip of islet, Lopez 3; Toki Point [w. tip of Peale], McFarlane 26. These were mistaken at first for L. repens var. subulatus Fosb.

!*PASPALUM AURICULATUM Presl
Collected at FAA Dock, 1961, Sachet 903, not seen 1963.

*PASPALUM DISTICHUM L.
P. vaginatum Sw.
Several patches on Peale Islet, 1963. Examination of the type of P. distichum in the Linnean Herbarium, by C. E. Hubbard, showed that it is the widespread plant usually known as P. vaginatum Sw., characteristic of saline habitats, rather than the similar fresh-water marsh plant commonly known in North America and Hawaii as P. distichum.

!*PENNISETUM POLYSTACHYUM (L.) Schultes
Found sterile at FAA Dock 1961, Sachet 906, more abundant, fertile, same place 1963, Fosberg 43538; west end of runway, 1965, McFarlane 76.

*SETARIA VERTICILLATA (L.) Beauv.
Not seen 1961, 1963.

*SORGHUM DOCHNA var. TECHNICUM (Koern.) Snowd.
Not seen 1961, 1963.

*ZEA MAYS L.
Not seen 1961, 1963.

CYPERACEAE

*CYPERUS ROTUNDUS L.
Collected in old Japanese garden site 1961, Sachet 890, seen there again 1963, around FAA Club, in 1965, McFarlane 67; and several patches on Peale Islet, 1963. (First noted in 1953).

!*CYPERUS PUMILUS L.
Collected around old Japanese garden site 1961, Sachet 889, not seen 1963, the only record from Micronesia.

FIMBRISTYLIS CYMOSA R. Br.
Generally distributed, Fosberg 43534, Sachet 874 and 883. These are the form with 2 style branches and smooth plano-convex nuts sometimes called *F. atollensis* St. John. Both Sachet collections have unusually long spikelets for this species.

!*FIMBRISTYLIS DICHOTOMA (L.) Vahl
Collected at FAA Dock in 1961, Sachet 905, not seen 1963, not previously known from Wake, and uncommon on atolls.

PALMAE

*COCOS NUCIFERA L.
A number of small trees seen around buildings 1963, none more than 3 m tall.

ARACEAE

*CALADIUM sp.
Not seen 1961, 1963.

*DIEFFENBACHIA sp.
Not seen 1961, 1963.

!*PHYLLODENDRON OXYCARDIUM Schott
Seen in pot 1963.

!*PHYLLODENDRON UNDULATUM Endl. (?)
In pot 1963.

*RHAPHIDOPHORA AUREA (Lind. & Andr.) Birdsey
Scindapsus aureus (Lind. & Andr.) Engl.
Not seen 1961, 1963.

PONTEDERIACEAE

*EICHHORNIA CRASSIPES (Mart. & Zucc.) Solms-Laub.
Not seen 1961, 1963. Has undoubtedly disappeared as the cistern where it grew seems no longer present.

COMMELINACEAE

!*RHOEO SPATHACEA (Sw.) Stearn
Seen in pot 1963.

!*SETCREASEA PURPUREA Boom
Seen in pot, 1963.

BROMELIACEAE

*ANANAS COMOSUS (L.) Merr.
Not seen 1961, 1963.

AGAVACEAE

*CORDYLINE FRUTICOSA (L.) Goepp.
C. terminalis (L.) Kunth
Seen in pots, 1963, not very flourishing.

*SANSEVIERIA GUINEENSIS (L.) Willd.
S. roxburghiana of 1959 list.
Seen in pot, 1963.

AMARYLLIDACEAE

*ALLIUM sp.
Not seen, 1963.

*CRINUM sp.
Planted around buildings, not flowering, 1952, 1953, 1961, 1963.

*HYMENOCALLIS LITTORALIS (Jacq.) Salisb.
Not seen 1961, 1963.

CASUARINACEAE

*CASUARINA EQUISETIFOLIA L.
Commonly planted around buildings, some trees have reached 5 m tall, 1963.

MORACEAE

*FICUS CARICA L.
Still present and fruiting, 2 m tall, 1963.

*FICUS RUBIGINOSA Desf.
Not seen, 1961, 1963.

POLYGONACEAE

*COCCOLOBA UVIFERA (L.) L.
Still present 1961, 1963; on Peale Islet a fairly large tree in 1963.

NYCTAGINACEAE

BOERHAVIA REPENS L.
B. diffusa of 1959 list, not of L.
Common generally, 1961, Sachet 875, 893, 1963, in places very abundant Fosberg 43527.

BOERHAVIA sp. (white fls.)
The white flowered plant listed in 1959, occurring generally with B. repens, but less common, Fosberg 43530, 43518, Sachet 876, 892.

BOERHAVIA sp.
Occasional, apparently intermediate between the others, Sachet 891.

*BOUGAINVILLEA SPECTABILIS Willd.?
Seen around houses 1961, 1963.

PISONIA GRANDIS R. Br.
This, with Cordia, still formed a scrub forest 1961; in 1963 only scattered trees remained after pointless bulldozing of the one remaining area of original forest; scattered in open Tournefortia scrub base of Flipper Point Fosberg 43514.

AMARANTHACEAE

*AMARANTHUS DUBIUS Mart.
Found in 1952, and in 1961, Sachet 887; occasional locally in 1963.

*AMARANTHUS GRAECIZANS L.
Not seen, 1963.

*AMARANTHUS TRICOLOR L.
The specimen on which this record was based, Fosberg 34452, has been redetermined as A. dubius.

*AMARANTHUS VIRIDIS L.
Collected 1963 Fosberg 43517, very rare in open ground, Wake Islet.

AIZOACEAE

SESUVIUM PORTULACASTRUM L.
Common generally in low places, especially along lagoon margins and occasionally on flats near outer beaches, 1961, 1963. Stems unusually red -- this true generally in Wake plants, Sachet 864, Southwest arm of Wake Islet, flowers opening between 7 and 8 a.m.

PORTULACACEAE

PORTULACA LUTEA Sol.
Common, collected in 1961, Sachet 877; 1963, especially abundant in cleared area on west end of Wilkes Islet, Fosberg 43532. This is a very tall form, branches usually strongly ascending, light green, no trace of anthocyanin.

*PORTULACA OLERACEA L.
Collected in 1961, Sachet 868; seen in 1963; occasional around buildings and disturbed areas.

*PORTULACA SAMOENSIS v. Poelln.
Not seen 1961, 1963.

CRUCIFERAE

*BRASSICA OLERACEA va. ITALICA Plenck.
Not seen 1961, 1963.

LEPIDIUM BIDENTATUM Mont.
L. o-waihiense C. & S. of 1959 list (see Fosberg, Phytologia 15: 499, 1968).
Found in 1961, 1963. In 1963 the Lake Peale colony still persists even though the pond has been bulldozed out of existence. A large colony also located, flourishing, just back of beach at Kuku Point, Wilkes Islet, 1961, Sachet 879, 1963, Fosberg 43526.

*RAPHANUS SATIVUS L.
Not seen 1961, 1963.

CRASSULACEAE

*SEMPERVIVUM TECTORUM L.
Not seen 1961, 1963.

*KALANCHOE PINNATA (Lam.) Pers.
Persisting in IAS compound 1961, 1963.

LEGUMINOSAE

*BAUHINIA sp.
Not seen 1961, 1963.

!*DESMANTHUS VIRGATUS (L.) Willd.
Found in 1965 at the west end of the runway on Wake Islet, McFarlane 74.

!*LEUCAENA LEUCOCEPHALA (Lam.) de Wit
Seen on Peale Islet 1961, well established in same spot 1963, one plant seen also in IAS compound, 1963; apparently never collected on Wake.

*PHASEOLUS VULGARIS L.
Not seen 1961, 1963.

!*PHASEOLUS COCCINEUS L.?
One plant seen in garden, 1961, not seen 1963.

ZYGOPHYLLACEAE

!TRIBULUS CISTOIDES L.
Collected, Wilkes Islet near channel, 1961, Sachet 900, not seen, though searched for, 1963. Three plants only seen in 1961. It was collected in 1963 by McFarlane 1.

EUPHORBIACEAE

*CODIAEUM VARIEGATUM (L.) Bl.
Planted around houses, 1963, apparently thriving.

*EUPHORBIA CYATHOPHORA Murr.
Very common in 1961, perhaps somewhat less so, but still general in disturbed places, 1963.

*EUPHORBIA GLOMERIFERA (Millsp.) Wheeler
Common, locally abundant, 1961, 1963. Reaches a most unusual stature and woodiness here, Sachet 870, Fosberg 43520.

*EUPHORBIA HIRTA L.
Common in recently disturbed places, 1961, Sachet 871, 1963.

*EUPHORBIA PROSTRATA Ait.
Occasional in weedy places on Wake I. in 1961, Sachet 869, seen in 1963.

*EUPHORBIA PULCHERRIMA Willd.
Not seen 1961, 1963.

!*EUPHORBIA THYMIFOLIA Ait.
Collected 1961, Sachet 902, not seen 1963.

!*EUPHORBIA TIRUCALLI L.
Seen in pot in housing area, 1963.

!*PEDILANTHUS TITHYMALOIDES (L.) Poit.
Collected in IAS compound 1961, Sachet 884, seen there 1963.

*PHYLLANTHUS AMARUS Schum & Thonn.
Flourishing colony at IAS compound, 1963, Fosberg 43524.

!*RICINUS COMMUNIS L.
Seen planted in IAS compound in 1961, persisting and apparently thriving in 1963.

MALVACEAE

ABUTILON ASIATICUM var. ALBESCENS (Miq.) Fosb.
A. albescens Miq.
Abundant around old Japanese garden site in 1961, Sachet 885 seen also near MATS area, not seen 1963.

GOSSYPIUM HIRSUTUM L.
G. religiosum of 1959 list.
Widespread, locally common, 1961, Sachet 882, 886 and 1963 Fosberg 43516. According to Paul Fryxell, who has raised Wake Island material in cultures, this is a form of the species not known elsewhere. S. G. Stephens, who has also raised it successfully from Wake Island seeds, refers to it as "a wild form of hirsutum of an unusual type."

*HIBISCUS (ornamental hybrid)
Seen in 1961, not in 1963.

SIDA FALLAX Walp.
Abundant on Wilkes Islet 1961, Sachet 880, 1963, Fosberg 43529, occasional elsewhere.

*THESPESIA POPULNEA (L.) Sol. ex Correa
Planted around housing areas, and apparently thriving, in 1963, as well as persisting in IAS compound. It was first found, on Peale I., by Branckamp in 1936 (BISH).

PASSIFLORACEAE

*PASSIFLORA sp.
Not seen 1961, 1963.

!*PASSIFLORA FOETIDA var. HISPIDA (DC.) Killip
Established at IAS compound, 1961, Sachet 884a, still doing well 1963; southwest corner of Wake I. Sachet 878, and in 1965, McFarlane 77.

CARICACEAE

*CARICA PAPAYA L.
Still persisting around IAS compound 1961, 1963.

CUCURBITACEAE

*CUCUMIS MELO L.
Not seen 1961, 1963.

*CUCURBITA PEPO L.?
Seen at MATS area 1961, not seen 1963.

LYTHRACEAE

PEMPHIS ACIDULA Forst. f.
Still abundant 1961, 1963, especially around lagoon shores; planted for hedges in housing area, 1963.

COMBRETACEAE

*TERMINALIA CATAPPA L.
Planted in several places and thriving 1963, fair sized tree at IAS compound 1961, 1963.

MYRTACEAE

*EUCALYPTUS CITRIODORA Hook.
Not seen 1961, 1963.

CACTACEAE

Several cacti seen in pots 1961, not seen 1963.

ARALIACEAE

!*BRASSAIA ACTINOPHYLLA Endl.
Seen in 1961, not in 1963.

*POLYSCIAS GUILFOYLEI (Cogn. & March.) Bailey
Seen planted near a house, 1963.

UMBELLIFERAE

*ANETHUM GRAVEOLENS L.
Not seen 1961, 1963.

*APIUM PETROSELINUM L.
Not seen 1961, 1963.

SAPOTACEAE

*CHRYSOPHYLLUM CAINITO L.?
Not seen 1961, 1963.

APOCYNACEAE

*CATHARANTHUS ROSEUS (L.) G. Don
Seen in many places, cultivated and established, 1961, 1963, Fosberg 43521.

*NERIUM sp.
Seen 1961, not 1963.

!*PLUMERIA OBTUSA L.
Seen planted around buildings 1961, 1963.

CONVOLVULACEAE

*IPOMOEA BATATAS (L.) Lam.
Not seen 1961, 1963.

IPOMOEA PES-CAPRAE ssp. BRASILIENSIS (L.) v. Ooststr.
Still common 1961, 1963.

IPOMOEA TUBA (Schlecht.) Don
Generally abundant except in the most recently bulldozed areas, 1961, 1963. Flowers open about dusk, close mid-morning.

BORAGINACEAE

CORDIA SUBCORDATA Lam.
Well distributed, locally common in wooded parts of island, 1961, 1963, Fosberg 43519. Forest of this species and Pisonia on Wake Islet destroyed 1963.

HELIOTROPIUM ANOMALUM H. & A.
Common generally, locally abundant, forming pure stands in open areas on south coast near Peacock Point, 1963. No floral dimorphism observed. All plants seen here have deeply lobed white corollas with a tiny yellow eye. Wilkes Islet, near Kuku Point, Fosberg 43528. Wake Islet, Sachet 866.

!*HELIOTROPIUM OVALIFOLIUM var. DEPRESSUM Cham.
First collected 1961 near FAA Dock, Sachet 904, still common there 1963 Fosberg 43537, doubtless introduced from Guam, where it is common.

TOURNEFORTIA ARGENTEA L.
Generally abundant 1961, 1963.

LABIATAE

*COLEUS SCUTELLARIOIDES L.
Still seen 1961, not seen 1963.

VERBENACEAE

!*STACHYTARPHETA JAMAICENSIS L.
Abundant near FAA Dock in 1963, inadvertently not collected. Depressed to ascending herb with pale blue-violet corollas, thick spikes. Collected by McFarlane 22.

!*STACHYTARPHETA URTICIFOLIA Sims
Collected in weedy area at n.w. tip of south arm of Wake Islet, 1961, Sachet 901. A tall shrub, to 2 m, with dark blue or purple flowers.

!*VITEX TRIFOLIA L.
First collected on Peale Islet in 1961, Sachet 896. Well established colony in 1963, plants several m tall.

SOLANACEAE

*CAPSICUM ANNUM L.
Not seen 1961, 1963.

*CAPSICUM FRUTESCENS L.
Not seen 1961, 1963.

*NICOTIANA TABACUM L.
Seen near power house, one plant only, in 1961, not in 1963, though possibly still persisting.

*SOLANUM LYCOPERSICUM L.
Seen in garden in MATS area 1961, not seen 1963.

ACANTHACEAE

!*PSEUDERANTHEMUM CARRUTHERSII Seem.
Seen in 1961, also var. atropurpureum, neither seen in 1963.

GOODENIACEAE

SCAEVOLA TACCADA (Gaertn.) Roxb.

S. sericea Vahl

Some plants still remain south of the main runway on Wake Islet, less in 1963 than in 1961, because of bulldozing; also seen planted around house on north side of islet.

COMPOSITAE

*CONYZA BONARIENSIS (L.) Cronq.

Collected south of runway in 1961, _Sachet 897_, common around old IAS compound and FAA Dock in 1963.

!*CONYZA CANADENSIS (L.) Cronq.

First collected south of runway in 1961, _Sachet 897a_, common around old IAS compound in 1963, also near FAA Dock, _Fosberg 43536_, west end of runway in 1965, _McFarlane 75, 79_.

*LACTUCA SATIVA L.

Not seen, 1961, 1963.

*PLUCHEA ODORATA (L.) Cass.

Very common to abundant in disturbed places generally, seemingly more so, especially on Wilkes and Peale Islets, in 1963 than 1961. Dominant in shrubby vegetation in various places.

*SONCHUS OLERACEUS L.

Not seen 1961, 1963.

CRYPTOGAMIC FLORA

!ALBUGO PLATENSIS (Speg.) Swingle

A common parasite on _Boerhavia repens_, _Fosberg 43511, 43531_. This species causes a change in habit, infested stems being erect and much shortened instead of prostrate and elongate.

!*UROMYCES EUPHORBIAE Cke. & Pk.

A parasite on _Euphorbia prostrata_, _Fosberg 43523_. This species, also, causes a change in habit in the host; infested stems are erect and the internodes are elongate.

Identifications of fungi by J. A. Stevenson.

337-682 O-69—5

ATOLL RESEARCH BULLETIN

No. 124

ECOLOGY OF TERRESTRIAL ARTHROPODS ON THE TOKELAU ATOLLS

by Alden D. Hinckley

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D. C., U. S. A.

March 30, 1969

ECOLOGY OF TERRESTRIAL ARTHROPODS ON THE TOKELAU ATOLLS

by Alden D. Hinckley[1/]

The Tokelaus are a chain of three atolls, south of the Phoenix Group and north of the Samoas. Distances (in statute miles) from Apia, Western Samoa, are approximately 300 to Fakaofo, 330 to Nukunono, and 400 to Atafu. Annual rainfall for each atoll is usually in excess of 100 inches but they have experienced long dry spells. Hurricanes occasionally pass through the group and several motus of Nukunono atoll were swept by waves in the storm of January 29 and 30, 1966.

During 1967, while I was employed as Ecologist on the United Nations - South Pacific Commission Coconut Rhinoceros Beetle Project, I spent 40 days in the Tokelaus. I went north from Apia on one of the last R.N.Z.A.F. Sunderland flights and returned aboard the "Aoniu", a Tongan copra boat. I visited Fakaofo on January 16-17 and February 25, Atafu on January 17-18 and February 24, and stayed on Nukunono from January 18 through February 23. Although my primary objective was to assess the Rhinoceros Beetle situation on Nukunono, I had time to make many other ecological observations.

For their help and hospitality, I would like to thank: Mr. Lloyd Weber, District Officer of the N.Z. Tokelau Administration; Father Mauga and the Marist Sisters; Mr. Morgan Williams of the "Tokrat" Project; all the people of the Tokelaus, especially my assistants Juliano and Sefo. I am also grateful for the determinations made by specialists associated with the British Museum and by Dr. Ernest Reese, University of Hawaii.

FAUNAL DIVERSITY

The only previous publication devoted primarily to Tokelau arthropods is one by Dale (1959) based on brief visits to each atoll in September, 1958. Laird's excellent 1956 monograph on Pacific Island mosquito ecology includes some Tokelau records and he subsequently used the atolls for pathological and chemical control experiments. Other surveys of terrestrial faunas on atolls include Gressitt (1952) on Kayangel in the Palau group, Niering (1963) on Kapingamarangi, a Polynesian outlier south of Ponape, Moul (1954) on Onotoa in the Gilberts, and Van Zwaluwenburg (1955) on Canton, in the Phoenix group. Perhaps the most complete study was made on Arno in

---

[1/] Visiting Ecologist, Brookhaven National Laboratory, Upton, L. I., N. Y., 11973, U. S. A.

the Marshalls by Usinger and LaRivers (1953). Gressitt (1954) estimated that the Arno fauna might include 500 species of terrestrial arthropods, some 300 having been collected by Usinger and LaRivers. Other estimates by Gressitt (1954) were 1,100 species for Kayangel and 170 for Onotoa. Van Zwaluwenburg (1955) recorded nearly 100 insects and 15 other arthropods from Canton.

In this paper, 177 species of Tokelau arthropods in 103 families (150 insects in 83 families) are listed in Table I. Most of these are probably common to all 3 atolls, the only definite exception being the Coconut Rhinoceros Beetle, Oryctes rhinoceros, so far confined to Nukunono. Other possible exceptions would be the milliped on Atafu and Aedes vexans on Fakaofo. I would guess that the total arthropod fauna on Nukunono is close to 400 (300 insects). The day I left, I was still finding species I had not seen before. I did not collect any bird or rat ectoparasites and I missed many arachnids. In terms of faunal diversity, it seems that Nukunono stands somewhere between Arno and Onotoa. It is certainly richer than Canton, only 450 miles to the north.

SPECIES ESTABLISHMENT, EXTINCTION AND DISPLACEMENT

Books by Elton (1958) and, more recently, MacArthur and Wilson (1967) have raised important questions about successful and unsuccessful colonization. As Laird (1956) showed, Anopheles almost certainly could become established on high islands in the Fiji and Samoa groups. Similarly, there are many "open niches" on atolls.

The Rhinoceros Beetle is a case in point. Well established on Cocos-Keeling atoll in the Indian Ocean and such Pacific high islands as Babelthuap, Palau, and Upolu, W. Samoa, the beetle has invaded 2 more atolls, Kayangel, 20 miles north of Babelthuap, and Nukunono, 330 miles north of Upolu. The colonizations apparently occurred about 1946 on Kayangel (Gressitt, 1952) and during 1964 on Nukunono. The behavior, adaptability and durability of the beetle make it a successful colonist. Adults fly at night, are attracted to light, and may land on cargo at a wharf or aboard a ship. The gravid female can survive long confinement in a hold and fly ashore to lay a clutch of 20-30 eggs in a rotten log, thus establishing the first cohort of a new species on the atoll. On Nukunono, Oryctes was, at first, found only on the village motu but the hurricane of January 1966 created a large supply of dead logs and the population increased ten-fold by January 1967, spreading to every large motu except Tokelau, the one farthest away from Nukunono village.

Many other colonizations have been successful in the Tokelaus. In Table I, those names marked with an asterisk are agricultural pests or "tramp species" which may have been introduced by man, including the original waves of Polynesian migrants. On the high islands of Fiji, Tonga, and Samoa, there are many other species which could presumably become established in the Tokelaus. The limited agriculture of the

Tokelaus is thus threatened by such pests as the Coconut Spike Moth, Tirathaba trichogramma (Meyrick); the Cluster Caterpillar, Spodoptera (ex Prodenia) litura (F.) which feeds on Alocasia and many other plants; the Scab Moth, Nacoleia octasema (Meyrick) which attacks Musa and Pandanus fruits; as well as many polyphagous scales and mealybugs. Of course, the establishment of many beneficial or economically neutral species is also possible.

Since there are so few records of earlier collections from the Tokelaus, it is not possible to say with certainty that species have died out or been displaced. However, the Tokelauans report that the Monarch Butterfly, Danaus plexippus (L.), has been established intermittently on Nukunono and Fakaofo, feeding on oleander (probably adults visiting flowers). It also seems likely that the dragonfly, Pantala flavescens (F.), dies out during prolonged dry periods on Nukunono, although it may persist in the deep wells of Atafu. This pattern of repeated establishment and extinction is common on arid, much-disturbed Canton (Van Zwaluwenburg, 1955).

Usinger and LaRivers (1953) reported an interesting displacement among the lygaeid bugs, Nysius spp., in the Marshalls and it is possible that similar events may have occurred in the Tokelaus or may occur some time in the future. However, so many niches are open or underutilized that the rate of establishment will exceed the rate of extinction (cf. MacArthur and Wilson, 1967), despite the small land area of the atolls, less than 2 sq. mi. for Nukunono and less than 1 sq. mi. for each of the others.

The sphinx moths of the Tokelaus provide a good example of 5 self-established species living in "peaceful co-existence". On Nukunono atoll, it was apparent that they seldom competed for adult or larval food, primarily because behavioral differences minimized niche overlap.

Sphingids of Nukunono Atoll:

	Agrius (Herse)	Apocalypsis (Hippotion)	Cephanodes	Chromis	Macroglossum
DISTRIBUTION	Nukunono motu	Tokelau motu	most motus	most motus	most motus
ABUNDANCE	rare	uncommon	very common	common	common
ADULT Flies	night	day	day	night	day
frequents flowers of	?Ipomoea	Pemphis	Morinda Pemphis ?Scaevola	?Morinda	Morinda
LARVA feeds on	Ipomoea	?Ipomoea ?Pisonia	Gardenia Guettarda ?Morinda	Morinda	Morinda

COMMUNITY ANALYSIS

Usinger and LaRivers (1953) attempted to classify the arthropod communities of Arno. Their system, reproduced as Appendix D in Wiens (1962), must be modified for application to the Tokelaus. They described communities associated with the Strand, Inner Beach, Open Woodland, Canopy Woodland, and Human habitations. For Nukunono, 5 plant habitats, each supporting characteristic arthropod populations, could be distinguished. These were: Inner Beach Shrubs, Village Gardens, Grass and Sedge, Coconut Groves, and Canopy Woodland. The first and last correspond roughly to those so designated by Usinger and LaRivers but the Tokelau coconut groves, with a palm density above 100 per acre, cannot be described as an Open Woodland. Only the mission plantation on Nukunono motu approaches this condition.

Detailed records of trophic relationships are presented in Table II but these, and other observations, can also be considered on a broader community basis:

Inner Beach Shrubs

These have been well described by Gressitt (1954), Fosberg (1960), and Wiens (1962). In the Tokelaus, *Pemphis* is most common on otherwise barren lagoon-side flats. *Scaevola* and *Messerschmidia* (*Tournefortia*) occur above the high water mark on both lagoon and ocean beaches. Uncultivated *Pandanus* also occurs in this zone.

Although no insects were recorded from *Pemphis* on Arno (Usinger and LaRivers, 1953), the noctuid semi-looper, *Achaea*, fed on it throughout the Tokelaus. Its populations may approach the "one-stage" condition. On the wave-washed clump of *Pemphis* next to the Fakaofo hospital, empty cocoons predominated but on the Tokelau motu of Nukunono, abundant larvae were defoliating the shrubs and on the village motu of Atafu, adults appeared to be the most common stage. Other insects feeding on *Pemphis* included a mealybug, *Planococcus*, and a small, unidentified caterpillar. As on Jaluit (*vide* Wiens, 1962, p. 447), a green lacewing, *Chrysopa*, was common near *Pemphis*. Flowers of *Pemphis* were frequented by such insects as the moth, *Piletocera*, and the bee, *Megachile*, which also visited other strand shrubs.

Scaevola supported not only the butterfly, *Precis*, and the dipterous leafminer, *Ophiomyia*, but also 2 sucking insects, the planthopper, *Ugyops*, and the polyphagous *Aphis gossypii*. The latter was attended by the equally ubiquitous ant, *Pheidole megacephala*, and preyed on by *Coelophora*. Many small wasps and flies were found on *Scaevola* leaves, possibly attracted by honeydew. They included the eurytomid, *Eudecatoma* sp., the scelionid, *Macrotelia* sp., the ceratopogonids, *Dasyhelea* spp., and the scatopsid, *Scatopse* sp. Also associated with *Scaevola* were adult derbids, *Lamenia* and *Swezeyia*, but adults in this family feed on the underside of many different kinds of leaves.

Messerschmidia made a small but colorful contribution to the strand community by nourishing larvae of the arctiid moth, *Utethesia*.

The inflorescences of Pandanus contained Docidothrips as well as mealybugs and caterpillars of Pyroderces. Birgus and other land crabs sheltered amidst the prop roots of Pandanus. Another crab was found with Aedes in broken, water-filled Pandanus stems.

Village Gardens

On each atoll, almost all the houses and gardens are, by tradition, confined to one motu. The gardens, with Alocasia, Musa, and some vegetables, are usually planted in pits filled with coconut husks and other debris. Near habitations, there are also some ornamentals such as Crinum, Gardenia, Polyscias and Nerium (oleander). In the village area, there are usually few coconut palms and a dense grove of breadfruit trees but the hurricane waves killed many breadfruit trees on Nukunono and scoured out the garden pits, although these had been partially restored at the time of my visit. West of the mission on Nukunono motu there is a plantation of a Pandanus variety especially good for fiber work.

This Pandanus showed feeding marks of Oryctes and the phasmatid, Graeffea. In the dead breadfruit wood, grubs of Oryctes and Dihammus were common. The Dihammus adults were conspicuous, resting on the leaves of many different plants but, as Dale (1959) noted, they did no damage. Damage by Oryctes adults to village palms was severe, 41% of the young fronds having been cut by beetle feeding in the growing tips. At the time of the survey, the beetle population on Nukunono motu and adjacent Motusaga was estimated to be 1,325.

Aphids were common in the gardens, Aphis gossypii on Alocasia and Pentalonia on Musa. The pits in which these plants were grown supported large numbers of roaches. Eggs of these were presumably parasitized by Evania and other stages eaten by the centiped, Scolopendra.

Gardenia bushes near the Nukunono hospital provided many trophic records. Aphis gossypii and Planococcus citri were sucking buds and leaves; sooty mold was growing on the honeydew; a psocid, Ectopsocus sp., was feeding on the mold; Pheidole was consuming both the honeydew and the psocids; and dipterous predators were also active, a syrphid attacking the aphid and a cecidomyiid attacking the mealybug. Other predators were present, Aleurodothrips, and the mite, Typhlodromus, but their roles were not clear.

Grass and Sedge

This association was the most restricted, being observed in a few unshaded areas such as the Nukunono mission and the church foundation at Fakaofo. Despite their limited extent, these patches of sparse grass and slightly denser sedge provided some interesting sweep net catches.

Aiolopus, the only grasshopper observed during the survey, was collected in this habitat. So also were the leafhoppers, Balclutha, Deltocephalus and Exitanus, the planthopper, Corbulo, the lygaeid,

Pachybrachius, the mirid, *Trigonotylus*, and the thrips, *Haplothrips*. Presumably the leafminer, *Phytomyza* (collected by Dale), and the Lawn Armyworm, *Spodoptera*, would be found here, too.

Many of the flies swept from grass and sedge were apparently "just resting", although some may have been feeding on pollen, etc. They included *Allotrichoma*, *Dasyhelea*, *Drapetis*, *Drosophila*, *Lamprolonchea*, *Limonia*, *Musca*, and *Trypaneoides*.

Coconut Groves

As indicated above, these are generally quite dense. Nut harvesting is intermittent and many non-bearing volunteers struggle to survive amidst the understory of *Guettarda* and *Morinda*. Ground cover, such as it is, consists of clumps of ferns, *Asplenium* and ?*Nephrolepis*. Also found in some coconut groves are trees such as *Calophyllum inophyllum*, *Cordia subcordata*, and *Hernandia sonora*, as well as the shrubby *Ficus tinctoria*. These conditions prevail over most of the uninhabited motus in the Tokelaus.

On the coconut palms, the most common phytophage was the Flat Moth, *Agonoxena*, but neither it nor the Stick Insect, *Graeffea*, reach damaging levels in the Tokelaus, although the latter can be devastating in the Gilberts. The only coconut pests important enough to merit control efforts were the Rhinoceros Beetle, *Oryctes*, and the Polynesian Rat, *Rattus exulans* (Peale). Various flies frequented the coconut inflorescences and *Pyroderces* larvae fed on the male flowers. Water catchment holes ("tungu") carved in palm bases, together with old, rat-chewed nuts, were major sources of *Aedes* in the groves.

The very numerous *Morinda* shrubs had the widest range of associated insects. *Aphis gossypii* on leaves and *Pinnaspis* on fruits were commonly attended by *Pheidole* and other ants which may have also obtained nourishment from flowers and extrafloral nectaries. The syrphid, *Xanthogramma*, preyed on the aphid and an aphelinid parasitized the scale. *Morinda* fruits were punctured by the pentatomid, *Pegala*, and its flowers were visited by flies such as *Cadrema*, *Dacus*, *Drosophila*, *Homoneura*, *Pseudorichardia*, and *Trypaneoides*. The nectar was also used by sphinx moths and the larvae of 2 species, *Chromis erotus* and *Macroglossum hirundo*, chewed large sections from *Morinda* leaf edges.

Caterpillars common on *Guettarda* were the hornworm, *Cephanodes*, and the leafroller, *Chloauges*. Some leaves of the few *Ficus* shrubs on Nukunono motu had been chewed and 2 larvae, presumably those of *Euploea lewenii*, were collected from *Ficus* on Fakanava motu. *Callopistria* and *Piletocera* moths were often seen flying over ferns, and larvae of the former may have chewed young leaves on *Asplenium*.

In coconut and other logs, not only *Oryctes* grubs but also the tenebrionid, *Amarygmus*, 3 species of termites, and 4 species of mites, were found. However, millipeds were found only on Atafu, possibly

because the ground is slightly higher and some soil has developed. Isopods, crabs, centipeds, earwigs, and small beetles were seen under logs.

Canopy Woodland

This association, which may resemble the original vegetation of the Tokelaus, has the same lower strata as the coconut groves: i.e., ferns, then *Morinda* and *Guettarda*. *Sida* and other shrubs may also be present. However, the upper canopy is formed by various combinations of *Cordia*, *Guettarda*, and *Pisonia*. Breadfruit may be planted in these areas but there are few other agricultural incursions. In this respect it differs from the canopy on Arno where giant breadfruit trees were dominant (Usinger and LaRivers 1953). On Nukunono atoll, the canopy woodland is found in the center of Tokelau motu, the south end of the long motu, and the west end of Nukunono motu.

Many of the *Morinda* and *Guettarda* insects found in coconut groves also occurred under canopy woodland. The leaffolder, *Eucosma* sp., on *Cordia* is another species which occurred in both communities. Perhaps *Hypolimnas*, a colorful nymphalid with great variation in patterns, was the most conspicuous insect found in the canopy woodland. Its caterpillars and chrysalides were common on *Sida* in the central part of Tokelau motu. The gryllid, *Anaxipha*, and the derbid, *Lamenia*, were also collected on *Sida*.

Many fairy terns and noddies nest in the canopy. Their ectoparasites, and arthropods found in their guano, would represent other important components in the woodland community of the Tokelaus.

SUMMARY

During January and February 1967, an ecological survey of the Tokelau atolls showed that at least 160 species of terrestrial arthropods were present. They are listed, together with earlier records, in Table I. Their observed food relationships are summarized in Table II.

The faunal diversity of the Tokelaus is discussed and it is concluded that Nukunono has fewer species than Arno in the Marshalls but more than Onotoa in the Gilberts. It is also concluded that the Tokelau atolls have many functional niches open or partially open, and that further accidental colonizations by high island species are quite probable.

The arthropods of the Tokelaus are also analyzed by their community relationships. For this purpose, 5 communities are recognized: Inner Beach Shrubs; Village Gardens; Grass and Sedge; Coconut Groves; Canopy Woodland.

REFERENCES

Dale, P. S. 1959. Notes on some insects and other invertebrates collected in the Tokelau Islands. N.Z. Ent. 2(4): 1-8.

Elton, C. S. 1958. The ecology of invasions of animals and plants. London: Methuen. 1-181.

Fosberg, F. R. 1960. The vegetation of Micronesia. I. General descriptions, the vegetation of the Marianas Islands, and a detailed consideration of the vegetation of Guam. Am. Mus. Nat. Hist. Bull. 119(1): 1-75.

Gressitt, J. L. 1952. Description of Kayangel Atoll, Palau Islands. Atoll Res. Bull. 14. Dec. 15.

__________ 1954. Insects of Micronesia. Introduction. Bishop Mus. 1: i-viii, 1-257.

Laird, M. 1956. Studies of mosquitoes and freshwater ecology in the South Pacific. Roy. Soc. N.Z. Bull. 6: 1-213.

MacArthur, R. H. and E. O. Wilson. 1967. The theory of island biogeography. Princeton Univ. Press. i-xi, 1-203.

Moul, E. T. 1954. Preliminary report on land animals at Onotoa Atoll, Gilbert Islands. Atoll Res. Bull. 28. May 31.

Niering, W. A. 1963. Terrestrial ecology of Kapingamarangi Atoll, Caroline Islands. Ecol. Monogr. 33(2): 131-160.

Usinger, R. L. and I. LaRivers. 1953. The insect life of Arno. Atoll Res. Bull. 15. April 30.

Van Zwaluwenburg, R. H. 1955. The insects and certain other arthropods of Canton Island. Atoll Res. Bull. 42. Aug. 15.

Wiens, H. J. 1962. Atoll environment and ecology. New Haven and London: Yale Univ. Press. i-xxii, 1-532.

Wilson, E. O. and R. W. Taylor. 1967. The ants of Polynesia. Pac. Ins. Monograph 14: 1-109.

Table I. TERRESTRIAL ARTHROPODS IN THE TOKELAUS

* Possibly introduced by man.

A - Atafu
N - Nukunono
F - Fakaofo

CRUSTACEA

ISOPODA

Armadillidae	
*Melanesillo hebridarium (Verhoeff)	Dale (1959)
Ligiidae	
*Ligia vitiensis Dana	"
Rhyscotidae	
*Rhyscotoides parallelus (Budde-Lund)	"

DECAPODA

Coenobitidae	
Birgus Latro (L.)	A N F
Coenobita brevimanus Dana	N

C. perlatus H. Milne Edwards	N
Grapsidae	
Geograpsus grayi (H. Milne Edwards)	A N F
Gen. & sp. indet.	N

CHILOPODA

SCOLOPENDROMORPHA	
Scolopendridae	
Cryptops sp.	N
Otostigmus sp.	N F
**Scolopendra morsitans* L.	A N F
GEOPHILOMORPHA	
Mecistocephalidae	
Mecistocephalus sp.	N

DIPLOPODA

JULIFORMIA	
Spirobolidae	
?Spirostrophus naresii (Pocock)	A

ARACHNIDA

CHELONETHIDA	
Indet.	N
SCORPIONIDA	
Buthidae	
**Isometrus maculatus* (DeGeer)	A N F
ACARINA	
Ascidae	
Proctolaelaps sp.	N
Epilohmanniidae	
Epilohmannia cylindrica (Berlese)	N
Hermanniidae	
Phyllhermania sp. nr. *foliata* Hammer	N
Phytoseiidae	
Typhlodromus caudatus Berlese	N
Rhodacariidae	
Olgamasine sp.	N
Uropodidae	
?*Fuscuropoda* sp.	N
ARANEIDA	
Argiopidae	
Araneus theisi (Walck.)	A N F
Eusparassidae	
**Heteropoda venatoria* (L.)	N
Pholcidae	
Smeringopus elongatus Vinson	N

Salticidae
    *Ascyltus pterygodes (L. Koch) .... A N F
    Bavia aericeps Simon .... N
    Flacilla sp. .... A

INSECTA

COLLEMBOLA
  Entomobryidae
    Seira (or Drepanocyrtus) sp. .... N (Laird, 1956)

THYSANURA
  Lepismatidae
    Gen. & sp. indet. .... N

ODONATA
  Libellulidae
    Pantala flavescens (F.) .... A (Laird, 1956) N

ORTHOPTERA
  Acrididae
    Aiolopus dubius (Willemse) .... N
  Blattidae (s.l.)
    *Blatella notulata (Stål) .... N
    *Cutilia nitida (Brunner) .... N
    *C. soror (Brunner) .... N
    *Periplaneta americana (L.) .... N
    *P. australasiae (F.) .... N
    *Pycnoscelus surinamensis (L.) .... N
  Gryllidae
    Anaxipha sp. .... N
    *Gryllodes sigillatus (Walker) .... N
    ?Ornebius novarae (Saussure) .... N
  Phasmatidae
    *Graeffea crouani (LeGuillou) .... A N F
  Tettigoniidae
    Phisis pallida (Walker) .... N F

ISOPTERA
  Kalotermitidae
    *Glyptotermes xantholabrum (Hill) .... N F
    *Incisitermes repandus (Hill) .... N F
  Rhinotermitidae
    *Prorhinotermes inopinatus Silvestri ..... N

DERMAPTERA
  Chelisochidae
    *Chelisoches morio (F.) .... N

PSOCOPTERA
  Ectopsocidae
    Ectopsocus sp. .... N

THYSANOPTERA

Phlaeothripidae

Aleurodothrips fasciapennis (Franklin)		N	
Haplothrips gowdeyi (Franklin)			F

Thripidae

Docidothrips sp.		N	

HEMIPTERA

Aphididae			
*Aphis gossypii Glover	A	N	F
*Pentalonia nigronervosa Coquillet	A	N	F
Cicadellidae			
Balclutha incisa Matsumura (= Nesosteles tutuilana Osborn)		N	
Deltocephalus sp. nr. hospes Kirkaldy			F
Exitanus capicola (Stål)		N	
Coccidae			
*Coccus hesperidum L.		N	
Delphacidae			
Corbulo dodona Fennah		N	F
Ugyops oromedon Fennah	A	N	F
Derbidae			
Lamenia caliginea Stål	A	N	
Swezeyia lyricen Kirkaldy (?= S. maurellei Muir in Dale 1959) ...		N	
Diaspididae			
*Pinnaspis strachani (Cooley)	A	N	F
Gerridae			
Halobates kelleni Herring		N	
Lygaeidae			
Pachybrachius pacificus (Stål)		N	
Miridae			
Trigonotylus dohertyi Distant		N	
Pentatomidae			
Glaucias sp.		N	
Pegala biguttula Hagl.	A	N	
Pseudococcidae			
*Dysmicoccus brevipes (Cockerell)	A		
*Planococcus citri (Risso)		N	F
*Pseudococcus sp. (in Dale, 1959)	A	N	F
Reduviidae			
Gen. & sp. indet.		N	

NEUROPTERA

Chrysopidae			
Chrysopa basalis Walker	A	N	F

LEPIDOPTERA

Agonoxenidae			
Agonoxena argaula Meyrick	A	N	F
Arctiidae			
Utetheisa pulchelloides Hampson	A	N	F

Cosmopterigidae	
Batrachedra sp. ? psilopa Meyrick	N
?Labdia sp.	N
Pyroderces paradotis Meyrick	N
Trissodoris honorariella Walsingham	N
Geometridae	
Chloroclystis sp.	A
Lyonetiidae	
Commodica sp. ? lucinda Meyrick	N
Decadarchis sp. ? carpophthora Meyrick ..	N
Noctuidae	
Archaea janata L.	A N F
Callopistria nauticorum Tams	N
Spodoptera acronyctoides Guenee	N
Tiridata samoana Butler	N
Nymphalidae (s.l.)	
Euploea lewenii Feld.	N
Hypolimnas bolina L.	N F
Precis villida F.	A N F
Pyralidae (s.l.)	
Cadra (or Ephestia) cautella (Walker) ...	A (Dale, 1959) N
Chloauges woodfordii Butler	A N F
Piletocera signiferalis Wlgrn.	A N F
Sphingidae	
Agrius (or Herse) convolvuli (L.)	N
Apocalypsis (or Hippotion) velox (F.) ...	A N
Cephonodes armatus Rothschild and Jordan	A N F
Chromis erotus eras Boisduval	N
Macroglossum hirundo samoanum R. & J. ...	N F
Tortricidae	
Eucosma sp.	N

DIPTERA

Agromyzidae	
Ophiomyia cornuta Meijere	A N F
*Phytomyza apicata Malloch	N (Dale, 1959)
Asilidae	
Despoticus sp. nr. simmondsi Bezzi	N
Cecidomyiidae	
Gen. & sp. indet.	N
Ceratopogonidae	
Dasyhelea spp.	N
Chironomidae	
?Orthosmittia sp.	N
Chloropidae	
Cadrema bilineata Meijere	N (Dale, 1959)
C. pallida Loew	N
Culicidae	
*Aedes polynesiensis Marks	A N F
*A. vexans nocturnus (Theobald)	F (Laird, pers. com., 1968)

Dolichopodidae
- *Chrysosoma complicatum* Beck .... N
- Gen. nr. *Liparomyia* sp. .... N (Dale, 1959)

Drosophilidae
- **Drosophila errans* Malloch .... F
- *Drosophila* sp. .... N

Empididae
- *Drapetis* sp. .... F

Ephydridae
- *Allotrichoma* sp. .... F

Lauxaniidae
- *Homoneura acrostichalis* Meijere .... N
- *H.* sp. ? *hawaiiensis* Malloch .... N
- *Trypaneoides* sp. nr. *carniventris* Bezzi . N

Lonchaeidae
- *Lamprolonchaea aurea* Macq. .... N F

Muscidae
- *Hardyia* sp. nr. *australis* Malloch .... A (Dale, 1959)
- **Musca domestica* L. .... A N F
- **M. sorbens* Wied. .... A N F

Otitidae
- **Scholastes bimaculatus* Hendel .... A (Dale, 1959) N

Platystomatidae
- *Pseudorichardia flavitarsis* Macq. .... N

Sarcophagidae
- **Sarcophaga misera* Walker (= *S. dux* Thoms.) .... N

Scatopsidae
- *Scatopse* sp. .... N

Syrphidae
- *Xanthogramma scutellare* F. .... N

Tephritidae
- *Dacus passiflorae* Froggatt .... A (Dale, 1959) N

Tipulidae
- *Limonia* spp. .... N
- *L. subsaltens* Alexander .... N
- *Styringomyia* sp. .... N

Ulidiidae
- *Euxesta semifasciata* Malloch .... F

COLEOPTERA

Anthicidae
- **Anthicus* sp. ? *oceanicus* Laferte .... A (Dale, 1959)

Anthribidae
- Gen. & sp. indet. .... N

Cleridae
- **Necrobia rufipes* (Deg.) .... F (Dale,1959)

Coccinellidae
- *Coccinella repanda* Thnb. .... A (Dale, 1959)
- *Coelophora inaequalis* (F.) .... N

Cucujidae
- **Oryzaephilus mercator* (Fauv.) .... N

Dynastidae
*Oryctes rhinoceros (L.) .... N (only)
Hydrophilidae
Dactylosternum subsquatratum Fairm. ..... F
Lamiidae
*Dihammus fasciatus (Montr.) .... A N F
*Oopsis nutator (F.) .... A N
*Sybra sp. .... A (Dale, 1959)
Nitidulidae
*Carpophilus dimidiatus (F.) .... A (Dale, 1959) F
*C. maculatus Murr. .... A (Dale, 1959) F
Oedemeridae
Ananca bicolor (Fairm.) .... N
A. decolor (Fairm.) .... N
Pselaphanca lateritia (Fairm.) .... N
Sessinia livida (F.) .... A N F
Scolytidae
*Xyleborus affinis Eichh. .... N
Tenebrionidae
*Amarygmus hydrophiloides Fairm. .... N F
*Tribolium castaneum (Herbst) .... N

HYMENOPTERA
Aphelinidae
Gen. & sp. indet. .... N
Chalcidae
Brachymeria sp. .... N
Eucharitidae
Chalcura sp. .... A
Eulophidae
Hemiptarsenus sp. .... N
Gen. nr. Stenomesius sp. .... N
Eurytomidae
Eudecatoma sp. .... N
Evaniidae
*Evania punctaticeps Kieffer .... N
Formicidae
*Anoplolepsis longipes (Jerdon) .... N F
*Camponotus inconspicuus Mayr var. samoensis Santschi (? syn. of C. chloroticus Emery, see Wilson & Taylor, 1967) .... N
*Cardiocondyla sp. .... N
*Monomorium floricola (Jerdon) .... F (Wilson & Taylor, 1967)
Odontomachus simillimus Fr. Smith (= "haematoda L.") .... N F
*Paratrechina bourbonica (Forel) .... N
*P. longicornis (Latreille) .... F(W.&T.,1967)
*P. vaga (Forel) .... F(W.&T.,1967)
Pheidole fervens Fr. Smith .... F(W.&T.,1967)
*P. megacephala (F.) .... A N (Dale, 1959)
P. oceanica Mayr .... F(W.&T.,1967)
*Tapinoma melanocephalum (F.) .... N F
Technomyrmex albipes (Fr. Smith) .... F(W.&T.,1967)

*Tetramorium guineense (F.)	....	F(W.&T.,1967)
*T. simillimum (Fr. Smith)	....	F(W.&T.,1967)

Note: The species recorded from Fakaofo (F) by Wilson and Taylor (1967) were collected by E. H. Bryan, Jr. in 1924 and some, especially in Paratrechina and Pheidole, may have been displaced since then.

Megachilidae	
Megachile diligens buxtoni Perk. and Chees.	A N F
Scelionidae	
Macroteleia sp.	N
Sphegidae	
*Pison hospes Sm.	N
*P. iridipenne Sm.	N
Vespidae	
Parodynerus bicinctus F.	A N
*Polistes sp.	? F

Table II. TROPHIC RELATIONSHIPS OF TOKELAU ARTHROPODS

A. PHYTOPHAGOUS

Hosts: Scientific name	Family	English or Tokelau name
1. Alocasia sp.	Araceae	Ta'amu
Aphis gossypii		
Pseudococcus sp. (Dale, 1959)		
2. Artocarpus altilis	Moraceae	Breadfruit
Pseudococcus sp. (Dale, 1959)		
3. Asplenium nidus	Polypodiaceae	Lau Mea
?Calliopistria nauticorum		
4. Cocos nucifera	Palmae	Niu
Agonoxena argaula		
Diaspid scale		
Graeffea crouani		
Oryctes rhinoceros		
Pyroderces paradotis - male flowers		
5. Cordia subcordata	Boraginaceae	Kanava
Eucosma sp. - leaf-folder		
6. Ficus tinctoria	Moraceae	Mati
Euploea ? lewenii		
7. Gardenia sp.	Rubiaceae	Tiale
Aphis gossypii		
Cephonodes armatus		

	Coccus hesperidum			
	Planococcus citri			
8.	*Guettarda speciosa*	Rubiaceae		Pua Pua
	Cephonodes armatus			
	Chloauges woodfordii - leaf-roller			
9.	*Ipomoea* spp.	Convolvulaceae		Kumara
	Agrius convolvuli			
10.	*Messerschmidia argentea*	Boraginaceae		Tausunu
	Anthribid beetle			
	Utetheisa pulchelloides			
11.	*Morinda citrifolia*	Rubiaceae		Nonu
	Aphis gossypii			
	Chromis erotus eras			
	Macroglossum hirundo samoanum			
	Pegala biguttula			
	Pinnaspis strachani			
	Ugyops oromedon			
12.	*Musa* spp.	Musaceae	Banana	
	Pentalonia nigronervosa			
13.	*Pandanus* spp.	Pandanaceae		Whala
	Docidothrips sp. - male inflorescence			
	Graeffea crouani			
	Oryctes rhinoceros			
	Pseudococcid			
	Pyroderces paradotis			
14.	*Pemphis acidula*	Lythraceae		Gagie
	Achaea janata			
	Planococcus citri			
15.	*Pisonia grandis*	Nyctaginaceae		Pukavai
	Sphingid, ?*Apocalypsis velox*			
16.	*Saccharum officinarum*	Gramineae	Sugarcane	
	Dysmicoccus brevipes			
17.	*Scaevola taccada*	Goodeniaceae		Gasu
	Anthribid			
	Aphis gossypii			
	Ophiomyia cornuta - leafminer			
	Precis villida			
	Ugyops oromedon			
18.	*Sida* sp.	Malvaceae		Fau
	Hypolimnas bolina			

19. Various
    Megachile diligens buxtoni - leaf cutter.

B. XYLOPHAGOUS and SAPROPHAGOUS

1. Copra (rotten)
    Anthicus sp. (Dale, 1959)
    Cadra cautella "
    Carpophilus spp. "
    Periplaneta spp. "
    Scholastes bimaculatus

2. Flour sacks
    Oryzaephilus mercator
    Tribolium castaneum

3. Garden pits (with coconut husks, etc.)
    Cutilia spp.
    Periplaneta spp.
    Pycnoscelus surinamensis

4. Hermit crab (dead)
    Sarcophaga misera

5. Logs, stumps and dead branches
    Amarygmus hydrophiloides - coconut, etc.
    Dihammus fasciatus - breadfruit
    Epilohmannia cylindrica - coconut
    Glyptotermes xantholabrum- "
    Incisitermes repandus - "
    Olgamasine sp. - "
    Oopsis nutator - ?nonu
    Oryctes rhinoceros - coconut,breadfruit,pandanus, etc.
    Phyllhermonia sp.nr.*foliata* "
    Prorhinotermes inopinatus- pandanus
    ?*Spirostrophus naresii* - coconut
    Sybra sp. (Dale, 1959)
    Xyleborus affinis

6. Pandanus fruit (rotten)
    ?*Fuscuropoda* sp.
    Proctolaelaps sp.

7. Shelf fungus (on breadfruit stump)
    ?*Drosophila* sp.

8. Sooty mold (on gardenia)
    Ectopsocus sp.

C. ENTOMOPHAGOUS

1. *Agonoxena argaula* (pupae)
    Brachymeria sp.

2. Ant
    Chalcura sp.

3. Aphis gossypii
    ?Chrysopa basalis
    Coelophora inaequalis
    ?Phisis pallida
    Xanthogramma scutellare

4. Ectopsocus sp.
    Pheidole megacephala

5. Ophiomyia cornuta
    ?Hemiptarsenus sp.

6. Oryctes rhinoceros
    Coenobita spp.
    Pheidole megacephala
    Scolopendra morsitans

7. Periplaneta spp.
    ?Evania punctaticeps
    ?Scolopendra morsitans

8. Pinnaspis strachani
    Aphelinid

9. Planococcus citri

    Cecidomyiid

ATOLL RESEARCH BULLETIN

No. 125

RECONNAISSANCE GEOMORPHOLOGY OF RANGIROA ATOLL, TUAMOTU ARCHIPELAGO

by D. R. Stoddart

with LIST OF VASCULAR FLORA OF RANGIROA

by Marie-Hélène Sachet

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D. C., U. S. A.

March 30, 1969

Contents

Figures (following p. 44)

Plates

RECONNAISSANCE GEOMORPHOLOGY OF RANGIROA ATOLL, TUAMOTU ARCHIPELAGO

by D. R. Stoddart

I. GENERAL DESCRIPTION

A. Introduction

Rangiroa (Figure 1) is the largest atoll in the Tuamotu Archipelago, and since the institution of a regular air service, the most accessible; yet in common with other Tuamotuan atolls it has rarely been visited by scientists and is barely mentioned in the literature. Dana (1849) published brief notes following the Wilkes Expedition; but the only full account is that by Agassiz (1903). Agassiz's descriptions are, however, verbose and imprecise, and marred by misinterpretations of major atoll features. In the study of Tuamotuan atolls, a major reference point is provided by the reports of the 1952 Pacific Science Board Expedition to Raroia Atoll, led by N. D. Newell. Major reports resulting from this expedition are those of Newell (1953, 1956) on geology and geomorphology; Doty and others (1954), Doty and Morrison (1954), and Morrison (1954) on plant and animal systematics and ecology; Harry (1953) on ichthyology; and Danielsson (1954, 1956) on culture and economic life. More recently, Ranson (1962 and earlier papers) has published accounts of Hikueru and other atolls, and detailed work has been carried out in connection with the French weapons tests at Mururoa at the eastern end of the archipelago (Lalou and others 1966, Chauveau and others 1967). Since Agassiz's work at Rangiroa, Tercinier (1956) has published briefly on soils, and Ottino (1965) and Garanger and Lavondes (1966) have issued first reports on culture history. The atoll has been recently visited by Dr. M.-H. Sachet in 1963, and by Professor A. Guilcher and the present writer in 1965. Aubert de la Rüe (1964) has published a general account of the atolls of the Tuamotu Archipelago, though he did not visit Rangiroa.

Because of shortage of time, observations in 1965 were limited to the superficial morphology of the atoll rim at a series of sample locations chosen to illustrate diverse exposure environments. These locations covered the north, west and south rims of the atoll. No observations could be made at the eastern end of the atoll, But Dr. Sachet spent some time there in 1963, and thus information is available for points on the entire perimeter. This report consists of three parts:

(1) a brief general account of the gross form and environment of Rangiroa;

(2) the systematic description of transects around the atoll rim, with emphasis on details of morphology; and

(3) a summary of atoll geomorphology as known at present, with emphasis on the nature and form of carbonate rocks and unconsolidated sediments, and a suggested summary of recent geomorphic development.

B. Acknowledgements

This study would have been impossible without the hospitality and active help of M. Maurice Pomier, Director of the Tiputa station of the Institut de Recherches pour les Huiles et Oléagineux (I.R.H.O.). M. Pomier made it possible to visit all the locations described in this report, and gave a great deal of his time in assisting the work. Dr. Marie-Hélène Sachet first drew my attention to Rangiroa, and was tireless in making arrangements for my visit. Finally, I thank the Royal Society of London, for the opportunity to visit French Polynesia following the Royal Society Expedition to the British Solomon Islands in 1965.

C. Gross Form of Rangiroa

Rangiroa is situated towards the northwestern end of the Tuamotu Archipelago, a chain of atolls 600 miles long in the center of the Pacific Ocean (Figure 1). According to Menard (1964) the Tuamotus lie on the site of part of the foundered Darwin Rise. Rangiroa is 125 miles northeast of Tahiti, the largest of the reef-encircled volcanic Society Islands. Rangiroa is itself large enough to entirely contain the island of Tahiti within its lagoon: it has a maximum length of 54 miles (northwest-southeast) and breadth of 23 miles. Agassiz states (1903, 33) that it is "somewhat pear-shaped" in outline. In quantitative terms the shape may be expressed in a number of indices, of which the Ellipticity Index is most useful. Table 1 gives calculated shape indices for Rangiroa and for a sample of 99 other atolls. Rangiroa is thus rather more elongate or elliptical than the mean for atolls so far measured.

Table 1

Index	Rangiroa Atoll	Mean values for 99 atolls[1/]
I_e	3.59	2.87 (modal class 1.5-2.0)
F	0.22	0.35
R_c	0.43	0.57
R_e	0.53	0.64

[1/] Stoddart (1966)

The size of Rangiroa (Figure 2) is its most immediately striking characteristic: the peripheral reef is 137 miles long, and the atoll has a total area of 633 square miles. This compares with 189 miles and

902 square miles, respectively, for Kwajalein Atoll in the Marshall Islands, the world's largest atoll. Dimentional statistics for Rangiroa, derived from the 1:100,000 chart by Lt. d'Anglejan Chatillon, Mission Hydrographique en Polynésie Française 1959, together with data for Raroia and four Marshall Islands atolls, including Kwajalein, are given in Table 2.

The peripheral reef flats of the atoll vary considerably in width, being generally narrower on the windward and wider on the leeward sides. On the northern rim the flat is 350-700 yards wide; on the west rim 475-700 yards wide; and on the south rim 825-1175 yards wide. The greatest width is found at the eastern end of the atoll, where north and south rims meet in a sharp angle. In common with other Tuamotu atolls, much of the reef rim is covered with islands. As at Raroia, atoll land is most continuous on the narrowest rim, and least continuous where the rim is widest; rim dimensions in both cases are similar, though orientation is not the same (Newell 1965, 330). The 1959 chart of Rangiroa shows 241 islands, of which all except 10 are on the peripheral reef rim. Islands cover one-third of the area of the peripheral rim, compared with 35% at Raroia, and contrasting with less than 10% on some Marshall Island atolls.

There are two passes through the rim, both on the north or windward side. Avatoru, the widest, is 400 yards wide, with depths of up to 10 fathoms; it bifurcates lagoonward. Tiputa Pass is 330 yards wide, with least depths of 9 fathoms; it also has a patch reef with island on the lagoon side. The passes are charted at a scale of 1:15,000 in Admiralty Chart 1175. In both passes there are strong and complex currents; Agassiz found these to reach 4-1/2 - 8 knots (Agassiz 1903, 33-34). There is little information on the lagoon floor. Agassiz (1903, 36, 45) took soundings between Avatoru and Fenuaroa, and found a hard, fairly flat floor, reaching 14-16 fathoms in the center, with a wide area less than 5 fathoms near the south rim. Within the two passes the floor lies at depths of 10-15 fathoms. Scattered soundings during the 1959 survey gave five readings of more than 30 fathoms, with a maximum of 34.4 fathoms; this compares with a maximum of 30.1 fathoms at Raroia. There seem to be few lagoon patch reefs actually breaking surface in the central part of the lagoon, but a greater number rising to about 5 fathoms. Patch reefs are concentrated in the narrow eastern part of the lagoon, and along the western side. Apart from the islands on patches near the passes there are seven small islands on lagoon patch reefs.

Soundings on the outer slopes of the atoll average about 600 fathoms at distances of 2 to 4 nautical miles from the reef. Slopes are steepest to the north (1 in 3 to 1 in 4), east (1 in 3.6), and south (1 in 4), and least steep along the west side (1 in 6 to 1 in 7). Soundings by Agassiz show that the outer slopes on both north and south sides of the atoll are steepest near the reefs, and become gentler at depth.

Table 2

Atoll	Perimeter miles	Length miles	Breadth miles	Total area sq. miles	Lagoon area sq. miles	Reef area sq. miles	Island area sq. miles	Number of islands
RANGIROA 1/	137	54	23	633	583	50	16.6	241
Raroia 2/	56	27	9	154	131	23	8	280
Kwajalein 3/	189	80 4/	20 4/	902 4/	880	(c.22)	5.6 4/	92 4/
Rongelap 3/	93	33	20	426 4/	396	34	2.5 4/	58 4/
Eniwetok 3/	72	25	20	395 4/	360	32	2.5 4/	39 4/
Bikini 3/	66	26	15	267 4/	243	30	2.8	29 4/

Sources:

1/ 1:100,000 chart by Lt. d'Anglejan Chatillon, 1959.

2/ Newell 1956, 329-330.

3/ Emery, Tracey and Ladd 1954, 22.

4/ Fosberg 1956, 34 and Figure 10.

D. Climate and tides

The following summary of wind conditions in the Taumotus is taken from the Geographical Handbooks Series: Pacific Islands, volume 2 (1943), p. 195-196.

> "The trade winds blow over the archipelago throughout the year but are often disturbed; they are most regular from May to October and then blow freshly. Their mean direction is east, drawing to east-south-east from June to October, and then to east-north-east from November to May. At this latter period they are often light, and may alternate with heavy unstable squalls from north to south-west, these squalls being more frequent by night than by day. Strong winds from the south-east are liable to occur from May to September, but especially in August, when they are apt to last from four to eight days. From November to May, gales from north to south-west are relatively frequent, especially in January to March. In January a gale arising in the north-west usually shifts to north and north-east; at other times the tendency is for it to shift from north-west to south-west.
>
> "The Tuamotu group is subject to hurricanes, which occur as a rule towards the end of the year, or in January or February. Normally, however, they occur less than once in two years. Hurricanes (tropical cyclones) of particular force have been recorded in September 1877, February 1878, January 1903, and February 1906."

Climatic data for the I.R.H.O. Station at Tiputa, Rangiroa, are available since 1959. The mean annual rainfall for 1959-64 was 57 inches (1449 mm), but this figure conceals considerable variation from year to year. Rainfall tends to be highest in November-January, when it is also least reliable, and lowest in April-May and again in September. The scatter diagram of monthly rainfall over the period of record (Figure 3) shows this vividly. The range of actual monthly rainfalls recorded in each month even over this short period gives a similar impression, as shown in Table 3. Exceptionally high monthly figures appear to result largely from the rainfall received during single storms: in each of the years of record there was one storm yielding more than 100 mm of rainfall in a single day, with a maximum of 159.1 mm in one day in January 1965. These exceptional storms are well-distributed throughout the year (Figure 4), though with minima in May and September.

Other climatic data are less complete. Mean annual temperature in 1963 was 27.7°C and in 1964, 27.6°C. The variation in monthly means is approximately 3°C: from a minimum of 25.7-26.2° in July to a maximum of 28.8-29.3°C in February-March. Insolation is greater than 200 hours per month in all months except November and December, and totals between 2500 and 3000 hours per annum (1963: 2671 hours; 1964: 2893 hours). No wind or pressure records are kept at Rangiroa.

337-682 O-69—7

Table 3[1/]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
A:	370.8	292.5	224.5	212.5	340.2	248.0	98.8	171.0	94.7	286.5	496.1	321.4
B:	62.5	44.3	54.1	27.0	11.9	9.0	11.9	25.0	24.7	16.0	36.4	33.7

1/ Source: Rainfall records, I.R.H.O., Tiputa.

A. Maximum recorded for each month, mm, 1959-65

B. Minimum recorded for each month, mm, 1959-65

Newell (1956) summarized sea conditions affecting the Tuamotu atolls as follows:

(1) Prevailing trade winds from the east give heavy seas on the northeast or windward sides of atolls.

(2) Southern Ocean swell breaks heavily on the south or swellward sides of atolls.

(3) Occasional hurricanes or tropical storms strike atolls in their northwest or stormward quarter.

This framework may be conveniently used for categorizing the rims of Rangiroa.

According to Wiens (1962, 214) the spring tide range at Rangiroa is 2.1 feet; this compares closely with a little under 2 feet at Raroia (Newell 1956, 329).

II. THE NORTHERN OR WINDWARD RIM

A. General Characteristics

The northern reef flat varies in width from 350 to 700 yards, reaching a maximum of 1050 yards at its eastern end. It is approximately 50 miles long, and is surmounted by islands for some 85% of this length. Five of the islands are more than a mile long: most of the rest are between 200 and 600 yards in length, but show clear evidence of being dissected fragments of formerly longer islands. The two deep-water passes (*ava*) are found on the northern rim, to the west of the islands of Avatoru and Tiputa, respectively; on each of these two islands there is a village of about 300 people. At the lagoonward entrance of each pass there is a reef patch with a small island. The characteristics of the flat are described, first, with an island, and second, without.

(1) Reef rim with island.

The characteristics of the reef rim with island are shown schematically in Figures 5 and 6A. A cross-section of reef rim with island falls into three main divisions: (a) the seaward flat, (b) the island, and (c) the lagoon reef. The width of the seaward flat varies from 50 to 200 yards, and occupies roughly one-fifth of the width of the rim. It consists of a raised outer rim, with surge channels and living Porolithon to seaward (the "algal ridge" *sensu lato*): and a bare rock flat, partly drying at low water. Detailed transects of the seaward flat are given in Section IIB.

The islands (*motu*) are generally 250 to 400 yards wide. They are built almost entirely of shingle, with massive shingle and rubble ridges rising to heights of 10-15 feet above the reef flat on the seaward side. Lagoonward of these ramparts the surface falls fairly rapidly to a level of 6-8 feet above the flat, and declines lagoonwards.

The lagoon shore is formed by steep ridges of finer shingle. The lower part of the seaward shore almost invariably consists of an erosion ramp of worn, smooth conglomerate, sloping seawards at angles of 5-7° (Plates 1 and 2), and in many places overlain by topographically recognizable beachrock (Plate 3). The beachrock, with dips of 3-7° (maximum recorded 11-20°) normally follows the shore, but in places trends across the seaward flat at an angle to the shore to form outliers up to 80 yards distant from it. Seaward beach angles vary considerably: the beach face of rubble beaches may reach 14-18°, though angles as small as 6-1/2° were measured on small patches of sand beach. On the lagoon shore, though the relief is much less, angles remain steep: lagoon-facing slopes of successive beach ridges at Tiputa have angles of 10-13°, while the backslope of the ridges reaches 19° in places. At some points the lagoon ridges are being oversteepened by erosion, to give angles as high as 39° on the lagoon shore of Maheretetiae. In many islands, particularly towards the west, the steep lagoon ridges enclose an area of standing water or marshy ground (_tairua pape_): at Avatoru this measures 170 x 700 yards (Plate 8). After heavy rain the low-lying area surrounding the pools may be covered with two to three inches of standing water for a period of days. In addition to the pools surface depressions are also found in the form of taro pits (_maite_), formerly used for cultivation but now serving as depositories for organic rubbish and the growing of bananas and other plants.

The islands are separated by shallow, narrow channels known as _hoa_ (Plate 4). These are clearly erosional, and represent breaks in formerly more extensive islands. In the walls of islands transected by _hoa_, conglomerate rock is exposed underlying the island clastics and rising above the level of the reef flat. This conglomerate forms a ledge in the walls, and also floors the _hoa_ itself. Channels cut in the conglomerate by water passing from sea to lagoon are extending seaward by headward erosion, often terminating in small waterfalls with plunge pools. Erosion of the conglomerate is generally fronted by a flat erosion ramp representing the extent of marine planation. The height of the conglomerate varies: between Tiputa and Tepaetia, where the seaward beach ridges are not higher than 8 ft., the conglomerate stands three feet above the inner reef flat at the seaward end of the _hoa_, falling gradually to 1 ft. at the lagoonward end. The general dip of the upper surface of the rock is about 0.5; at the seaward end, stratification planes in the rock dip lagoonward at up to 1°. No seaward dips were seen. Much of the rock surface in the _hoa_ is undergoing onion-skin spalling of plates less than 6 inches in thickness, which once loosened are at times torn off bodily by wave action. Neither the conglomerate rock nor the erosion ramp immediately to seaward extends beyond the general line of the seaward or lagoonward shores of islands. In places similar rock forms horizontal outcrops 1-2 feet high and of small extent on the lagoon shores of islands. The lagoonward mouths of _hoa_ are often almost closed by spits and bars of fresh small coral shingle. On Mahereretiatae a relict _hoa_ was seen in the process of being recolonised by vegetation, after being sealed at both ends by beach ridges.

The lagoon reefs on the northern rim are poorly developed. A rather sparse growth of corals extends from the beach foot to the edge

of the lagoon slope, a distance of only 15-50 yards, where the bottom falls steeply to the lagoon floor at depths of 10-15 fathoms.

(2) Reef rim without island.

Reef rim lacking island was investigated between Moao and Hararu. Although no land is shown on the chart, the whole of this section resembles a normal _hoa_. The seaward flat is the same as that off islands, with seaward rim and bare rock-floored reef flat, together with occasional large reef blocks. The place of the island is taken by a platform of conglomerate rock, with a general level of less than 2 feet above the flat. The seaward edge of the conglomerate forms a low cliff overlooking an abrasion platform. Channels through the conglomerate are shallower and less clearly defined than in the _hoa_, and are often discontinuous; near the lagoon edge, however, they may become deeper, V-shaped scour notches only partly interrupted by bars. Along the seaward edge of the conglomerate platform there is no accumulation of rubble or shingle; but along the lagoon edge there is a zone 50 yards wide of high steep shingle ridges. The inner part of the conglomerate platform and the lagoonward ridges are covered with vegetation, mainly _Pemphis acidula_ and _Suriana maritima_ growing directly on the bare rock surface; the plant cover is sufficiently dense that, seen from the sea, the inter-island flat appears to be a vegetated island.

This description applies specifically to the 1-1/2 miles long Maoa-Hararu gap, which is one of the longest on the northern rim; whether other inter-island areas on this rim are comparable remains to be seen.

B. _Reef flat profiles_

The northern rim of Rangiroa was investigated at Avatoru, Tiputa, Tepaetia, Mahereretiatae, and eastwards to Hararu in the Moao-Hararu gap. Measured profiles of the seaward flat at these locations are given in Figure 7.

Profile 1

Avatoru, north shore, west end of the island. The reef flat has an average width of 170 yards, and the seaward beach of 20 yards. The following zones are recognized:

(a) _Porolithon_ zone of encrusting pink algae. The algae form a 'paint' over the surface of surge channels and inter-channel areas; the channels themselves pass seawards into the reef-front groove system. Apart from small and scattered _Porites_ and _Acropora_ in the surge channels, corals are absent. Slate-pencil urchins are conspicuous on the algal surface. In the channels the _Porolithon_ forms small, smooth-surfaced bosses up to 6 inches high and 6 inches in diameter; the channels themselves are 10-15 yards apart. From the inner limit of continuous _Porolithon_ to the wave break line the zone is 30-40 yards wide. At low water the zone emerges during backwash, but is covered by up to 2 feet of water during swash.

(b) Orange zone. This name is given to a highly distinctive zone of eroded rock at the same level as or slightly higher than the Porolithon zone; it consists of rimmed pools and holes coated with an orange alga. Zones (a) and (b) together comprise the outer ridge or, in a wide sense, the algal ridge, of the seaward flat. The orange zone is 20-25 yards wide. Its inner boundary is irregular, serrated by erosion channels formed by water pouring over the lip onto the flat itself. There are no growing corals in this zone.

(c) Reef flat. A rock-floored flat deepening from land to sea. The inner half dries completely at low water, when the outer part still carries up to 1.5 feet. Potholes near the junction with zone (b) contain a few small corals such as Pocillopora and Porites, but otherwise there are no growing corals on any part of the flat. The planed rock surface is very sparsely covered with a thin layer of mobile sand. Total width 100-110 yards.

(d) Beach-foot beachrock: a massive conglomerate, dipping seaward, forming a plate 5 yards wide and 1.5 feet thick along the foot of the beach; resting on an inclined rock surface which passes under the beach sediments and which is formed of a similar conglomerate to the beachrock.

(e) Beach face: white, unweathered coral shingle, 14 yards wide and rising to 8 feet above the level of the inner flat.

(f) Beach crest of blackened shingle with a hedge of Suriana maritima.

Profile 2

Tiputa, north shore, west end of the island. The reef flat is only 90 yards wide, and the rubble beach is correspondingly higher and steeper.

(a) Porolithon zone of smooth pink encrusting algae between surge channels, with small boss-like growths on channel walls. No growing corals; a few patches of green algae. When observed wave action was greater here than elsewhere on the reef edge: in very calm conditions waves at breaking reached heights of 1.5 to 2 yards, at times throwing spray to heights of 6 yards. The zone is at least 30 yards wide.

(b) Orange zone of eroded rock with large potholes and some sharp residual pinnacles. No pink algae. There are some corals in the deeper potholes. The zone is 10-25 yards wide, and rises 2 feet above the outer reef flat.

(c) Reef flat: a planed rock floor with a thin discontinuous cover of sand and no corals. Strong longitudinal currents move westwards towards Tiputa pass to remove water pouring over the raised rim. The flat deepens slightly from land to sea, and the inner part dries at low water, 35 yards wide.

(d) Beach-foot beach conglomerate: a rather heavily eroded massive conglomerate, dipping seaward, 5 yards wide.

(e) Beach face, 12 yards wide, rising steeply to 10 feet above the flat; built of white shingle with pockets of foraminiferal sand in the lee of the beachrock.

(f) Beach crest of dark unvegetated shingle - mostly coral fragments 3-9 inches long, recognisable to genus. The surface slopes gently upwards from the top of the beach face to a crest 17 yards inland, and then falls landwards to the vegetation hedge of Tournefortia argentea and Suriana maritima.

Profile 3

Tiputa, east of Profile 2, where the reef flat narrows to approximately 65 yards.

(a) Porolithon zone and surge channels. No corals.

(b) Orange zone of eroded rock; zones (a) and (b) together form a rim at least 30 yards wide (Plate 9).

(c) Rock-floored reef flat, possibly just drying in places at low water. No corals on the rock surface. In places there are linear residuals of rock which are probably old patches of beachrock. Width 35 yards.

(d) Beach-foot beachrock (Plate 3): a smooth inclined plate rising up to 3 feet above the inner flat level and passing under beach sediments. The rock contains large coral fragments, but hand specimens have the appearance of moderately infilled beachrock. Structural dip seawards.

(e) Beach face: a rather complex feature 30-40 yards wide, rising to a maximum height of 15 feet above the inner flat, mostly formed of grey shingle 4-6 inches long, with sand on the lower face.

(f) Beach crest of dark shingle, coarsening landwards. Declining in height towards the vegetation hedge which here consists mainly of Tournefortia argentea, with coconuts farther inland.

Profile 4

Tepaetia, north shore, midway along the island. The profile is narrow and comparable to Profile 3.

(a) Porolithon zone of pink encrusting algae 25 yards wide, with surge channels 5-10 yards apart.

(b) Orange zone, width 30 yards. The outer two-thirds of this zone is similar to that in Profiles 1-3: smoothly rounded potholes and ridges are covered with an orange-colored alga. The inner, landward third is formed of sharper pinnacles and ridges, with a local relief of 3-6 inches.

(c) Bare rock reef flat, 25-30 yards wide, lacking growing corals or other large colonial organisms, with only a thin, discontinuous sediment cover.

(d) Beach-foot beachrock: a massive, very stony conglomerate in two distinct bands, each with 2-3 layers, dipping seaward, 8-10 yards wide, and rising up to 1.5 feet above the inner flat.

(e) Seaward beach face: a shingle beach 15 yards wide, with most particles less than 2 inches long, and patches of foraminiferal sand, particularly in the lower part.

(f) Beach crest, forming a wide flat of shingle, with particle length greater than 9 inches, mostly corals but with blocks of beach conglomerate, presumably carried by storm waves. The crest stands 9 feet above the inner flat level. The outer part of the crest is covered with a low hedge of _Suriana maritima_: 35-40 yards inland this is replaced by a solid stand of _Guettarda speciosa_.

Profile 5

Mahereretiatae, north shore, west end of the island. The reef flat here is wide (160-180 yards) and thus comparable to Profile 1.

(a) _Porolithon_ zone of pink algae with many close-set groove-like surge channels averaging only 4 yards apart. Nodular _Porolithon_ is conspicuous at lower levels.

(b) Orange zone, 25 yards wide: the landward edge potholed and grooved, and clearly undergoing erosion.

(c) Rock-floored reef flat with a total width of 115 yards. Its outer part lies 2 feet below the level of the orange zone, but rises landward. No corals.

(d_2) In places on the reef flat there is a discontinuous zone of rock up to 1.5 feet high, jagged and eroded, forming narrow linear bands parallel with the shore. No structure is apparent, but these are probably relict bands of beachrock.

(g) The inner part of the reef flat is formed by a dark-colored bare rock platform, drying at low water, 20-25 yards wide, and of erosional origin. It stands up to 1 ft. above the general level of the reef flat, but there is not sharp line of demarcation between the two.

(d) Beach-foot beachrock: a conglomerate rock overlying the erosion platform; 4-5 yards wide, up to 1.5 feet high, and dipping seawards.

(e) Beach face, 20 yards wide and 6 feet high from the inner flat to the first vegetation hedge. The lower part of the face is sand and fine gravel; the upper part of medium shingle.

(f) Beach crest: a flat expanse of very coarse blackened rubble 40-50 yards wide and up to 9 feet above the flat, separated from the beach face by a narrow hedge of _Suriana maritima_ and disappearing inland under a thicket of _Tournefortia_, _Guettarda_, _Scaevola_ and _Hedyotis_.

Profile 6

Mahereretiatae, north shore, east end of the island. The reef flat is again wide and comparable with Profile 5.

(a) _Porolithon_ zone: as in Profile 5.

(b) Orange zone: as in Profile 5.

(c) Rock-floored reef flat, 90 yards wide, 1.5-2 feet below the level of the orange zone in its outer half, and rising towards the shore. There are some large reef blocks of storm-tossed origin, up to 5 feet high and 18 feet long on the flat from Mahereretiatae eastwards; one reef block in this profile stands 110 yards from the reef edge. There are no growing corals on the flat.

(g) The inner part of the reef flat is covered with coral rubble to form a boulder carpet up to 25 yards wide, overlying the erosional rock platform seen in Profile 5.

(d) Beach-foot beachrock, here a degraded conglomerate outcrop only 5 yards wide, with no clear form or structure, and largely covered with rubble blocks up to 1.5 feet in diameter.

(e) Beach face and crest. The unvegetated beach area here has a total width of up to 170 yards. The outer face, 6 feet high and 12 yards wide, is built of coarse shingle of 3-12 inch calibre; it is topped by a discontinuous fringe of _Suriana_ and _Tournefortia_. A 50 yard wide back slope of grey rubble, horizontal and unvegetated, is followed by a steep rise to a second ridge, 6 feet higher than the first, of blackened rubble. The backslope of this has a slight landward slope, and is formed of rough large coral blocks, tightly packed. The vegetation hedge (_Tournefortia_, _Guettarda_, _Hedyotis_ and some _Pandanus_) lies 60-100 yards back from the second beach crest.

III. THE WESTERN OR LEEWARD RIM

A. _General characteristics_

The western rim of Rangiroa is 17 miles long: of this distance 60% is covered with islands. The basic pattern is similar to that on the northern rim, with the division into seaward flat, island, and lagoon reef. Typical conditions were seen at Motutii and Tereiao (Section IIIB). Here the seaward flat, with a total width of about 120 yards, consists of an outer raised rim, bounding a rock-floored reef flat which towards the seaward shore of the island is covered by a platform of conglomerate rock. The islands are approximately 500 yards wide; five of them are considerably longer than the rest, which

are separated by hoa. The seaward beach ridges, facing away from the prevailing winds, are lower, less steep, and built of finer debris than the ramparts on the northern rim. Thus at Motutii the beach of fine shingle rises to 4-7 feet above the flat and has a mean slope of 6-9°. In places where the shore approaches closer to the reef edge, however, as on parts of Tereiao, the seaward ridge is higher (up to 10 feet), steeper (in places up to 20°), and built of coarser shingle. Lagoonward of the seaward beach crest, the surface declines fairly gently towards the lagoon shore: the seaward part is built of blackened gravel, the lagoonward part of sand. The lagoon beach is low and narrow, of either sand or fine shingle, and may enclose a narrow pool or marshy area (Plate 13). The main contrast in island form between the northern and western rims, therefore, is in the absence of sand-size material in the former and its importance in the latter. A further major difference is in the nature of the lagoon reef. On the western rim the lagoon reefs face 10-20 miles of open lagoon, in contrast to the sheltered leeward lagoon reefs of the northern rim. On the west rim the lagoon reefs form a sandy shelf at least 1 foot deep at low water, edged with living coral, and up to 200 yards wide.

At the areas investigated, the islands are separated by hoa in the sides of which conglomerate platforms outcrop. These are closely comparable to similar features on the northern rim. Thus at Motutii, where the seaward beach is 6 feet high, the conglomerate platform underlying it stands 1 foot above the flat. To the south, on Tereiao, where the seaward beach reaches 10 feet in height, the conglomerate platform rises to 3 feet at its seaward edge. In both cases the rock surface declines lagoonward. No conglomerate rock or beachrock was seen on the lagoon shore here; but at Tivaru, where the lagoon shore is sandy and up to 5 feet high, there are outcrops of beachrock trending at a slight angle to the modern beach.

This description applies to 'typical' islands of the western rim. This rim, however, is subject to hurricanes and resulting catastrophic modification. Such changes were seen at Maeherehonae, and may exist elsewhere. Here the seaward flat (Section IIB), of normal width, is littered for a distance of 1 mile with large reef blocks (Plate 18). Most of these are 6-10 feet high; the largest is a huge fragment of reef rock 18 feet high, 18 feet long, and 15 feet wide. The seaward beach is formed by a shingle rampart 6 feet high, and the seaward hundred yards of the island surface by a sea of boulders and coarse rubble, probably hurricane-deposited. The rest of the island surface, almost to the lagoon shore, is formed by a flat plain, partly of stripped conglomerate rock (exposed by overtipping wave scour?), partly of thin sand and gravel with discontinuous vegetation.

The lagoon shore of Maeherehonae is of especial interest. As at Tereiao it is sandy, faces a wide lagoon sand flat edged with reef, and encloses an extensive marsh area, up to 75 yards wide, with standing brackish to fresh water (Plate 14). At a distance of 150-200 yards from the lagoon shore, however, there is an extensive area of high dunes (one teitei), probably reaching a height of 30 feet and thus forming the highest land on the atoll (Plates 15 and 16). Conglomerate rock pavements can be seen beneath the dunes (Plate 17), and in

places in the pools near the lagoon shore; and farther cemented horizons can be seen in swales (often containing water) within the dune system itself. Gaps in the dunes are floored by shingle overlying the conglomerate platform. No lagoon shore dunes have been seen elsewhere. The dunes are vegetated, with Pandanus and Tournefortia, but with no continuous ground cover except dead Pandanus leaves. The Maeherehonae dunes thus represent an addition to the generalized island type shown in Figures 5 and 6.

No inter-island sections of reef flat (other than hoa) were seen on the west rim.

B. Reef flat profiles (Figure 8)

Profile 7

Tereiao, west shore, near the north end of the island.

(a) Porolithon zone, up to 60 yards wide (Plate 10). Three subzones can be distinguished: a lower part with grooves in the area of wave-break; a seaward-sloping section 30 yards wide of rather irregular topography, with erosional pillars and potholes and local relief of 1 foot, covered in pink algae but lacking surge channels; and a flat, regular, uneroded pink algal pavement 25 yards wide, with many scattered small encrusting Porites. The surge channels are here clearly much less extensive in the upper, inner part of the Porolithon zone than they are on the northern rim.

(b) Orange zone, 40 yards wide. The outer ten yards (b_2) is a strip of bare rock, without pink algae but with orange coloration; the rest is typically irregular, with potholes and ridges.

(c) Rock-floored reef flat 95 yards wide, with no growing corals but with a sparse gravel and sand cover.

(d) Conglomerate rock platform, 45 yards wide, rising up to 3 feet above the inner flat, and passing landward beneath the seaward beach. The rock is horizontal and shows no seaward dip (Plate 11).

(e) Seaward beach face, up to 7 feet high and 20 yards wide, of fine white shingle.

(f) Seaward beach crest, of blackened gravel (Plate 12), mean length about 6 inches, falling slightly lagoonward, with a covering of Guettarda and Tournefortia and a seaward fringe of Suriana and scattered Scaevola. Height 4-9 feet.

Profile 8

Maeherehonae, northwest shore, near the north end of the island. This profile differs considerably from the others reported here, presumably as a result of hurricane effects.

(a) Reef edge. The margin here is very irregular and broken: there are no surge channels and no algal ridge or similar feature. The surface lies at a lower level than in other profiles, and is covered with dead Pocillopora colonies coated with pink algae, to a distance of 30 yards from the edge.

(c) Reef flat. The reef flat proper is about 100 yards wide. It is littered with large reef blocks jumbled together; the largest is 18 feet high, the rest mostly 6-10 feet high. Between the blocks the surface is covered with living Pocillopora growing so closely together that it is difficult to see the underlying surface. To landward of the blocks, in calmer water, the Pocillopora is replaced by encrusting Acropora and Porites covering perhaps 10% of the total area.

(e) Seaward beach, 25 yards wide, built of boulders and shingle, rising 6-9 feet above the flat. There is no beach-foot beachrock or conglomerate.

(f) Beach crest: a boulder field with scattered Tournefortia.

IV. THE SOUTHERN OR SWELLWARD RIM

A. General characteristics

The southern rim of the atoll, facing the Southern Ocean swells, is 57 miles long; only one-third of this length is covered by islands, the smallest proportion of the three atoll rims. The southern rim, in addition, has characteristics not found at other parts of Rangiroa: these are shown schematically in Figures 9 and 6B, and elaborated in the detailed profiles 9-11 (Section IVB; Figure 10).

(1) Reef rim with island.

From observations at Porahu, Peari, Vaihoa and Utoto, a basic fourfold division may be made in the morphology of reef rims with islands on the south side of Rangiroa, into (a) the seaward reef flat; (b) the feo; (c) the island; and (d) the lagoon flat and reef. The southern rim is appreciably wider than the northern one, ranging from 800 to almost 1200 yards. The seaward reef flat itself is 100-120 yards wide: its outer edge, with its Porolithon and Orange zone margin, is similar to that elsewhere; but there is no well-developed rock-floored reef flat at or near low water level, as on the north and west rims. Instead, the inner part of the reef flat is occupied by bare swells of exfoliating reef rock, spalling off concentric sheets up to 1 foot in thickness (Plates 22 and 23). This is seen on a much smaller scale on conglomerate rock in some of the northern hoa. The exfoliating rock rises perhaps 2-3 feet above low water level, and is succeeded landward by a narrow and discontinuous rock-floored moat. The feo, lagoonward of the seaward flat, is a strip of elevated reef rock 80-120 yards wide, which evidently extends along the whole of the southern rim of the atoll (Plates 19, 20, 26, 27). It is deeply and intricately eroded, and intersected by narrow, deep and winding channels. The general level of its summit is 6 feet above the flat; some pinnacles

reach 9 feet. Characteristically, on its seaward side there is a low platform 10-45 yards wide of eroded feo, presumably cut down towards the level of the flat by marine erosion. The seaward flat and the feo together, with a width of more than 200 yards, account for about a quarter of the total width of the southern rim.

Islands account for rather less than half the width of the rim where observed (though some of the larger islands, such as Fenuaroa, Otepipi and Ovete are much wider). The seaward beach is usually lodged on the upper surface of the feo (Plate 26), though infrequently, as in Profile 9, there is a low area of rock-floored moat between feo and island (Plate 19). The seaward beach is usually narrow, low and sandy: incipient dunes were seen capping it at Utoto, where the crest rises to about 13 feet above the reef flat. The island surface and lagoon shore are mainly sandy, with fine gravel in places. At Porahu, under dense vegetation, the surface is covered with 3-6 inches of humus overlying phosphate rock within 40 yards of the shore. In the hoa between islands, conglomerate rock is exposed in the walls, dipping gently lagoonward, as elsewhere on the atoll rim. In the Peari-Vaihoa hoa (Plate 24) this conglomerate rock reaches to within 60 yards of the feo, and outcrops in the hoa walls for some 500 yards. The islands themselves are generally low, and the conglomerate platform is consequently a foot or less in height. Beach rock is found on the lagoon shore in places, though probably often covered by fresh sand spits and bars. Pools of standing water are ponded in places by the lagoon beach ridges.

The lagoon reef flat is exceptionally wide, reaching 250 yards: coral grows over much of its surface, and edges the flat. The approach to the islands is consequently difficult.

(2) Reef rim without island.

The only extensive inter-island tract seen was that between Porahu and Topitiiti. Here the seaward flat and feo are the same as elsewhere on the southern rim, but the rest of the rim surface carries at least 2 feet of water at low tide, has a sandy bottom, and is covered with large microatolls. Near the lagoon edge the floor shoals and is covered with linear sandbores. This is the only sector of reef flat seen on the Rangiroa rim with appreciable coral growth and no conglomerate platform.

B. Reef flat profiles (Figure 10)

Profile 9

Porahu, south coast, west end of the island.

(a) *Porolithon* zone, with grooves outside the wave-break line and small surge channels inside it. The pink algae form both small knobs and a paint-like coating on the surface; scattered large gastropods are also coated with pink algae. The inner part of the zone forms a slight moat. Width 35 yards.

(b) Orange zone, 25 yards wide, rising about 1 foot above the *Porolithon* zone: the surface is irregular, with ridges and potholes, and sinuous deeper channels cutting back into and through the zone from the seaward side.

(j) Zone of smooth exfoliating reef rock, light grey in color, with white patches where spalling rock shells have been dislodged by wave action. Width 50 yards.

(k) Narrow, rock-floored moat 5 yards wide and up to 1.5 feet deep: no corals.

(h_2) Zone of abraded *feo*, 44 yards wide, forming a low, rough-surfaced platform up to 3 feet in height, extending upwards from the moat to the *feo* proper.

(h_1) *Feo*, zone of elevated reef rock (Plate 20), dissected by deep through-channels, and intricately eroded into spires and pinnacles. The general elevation of the tops of the spires is 6 feet; some rise to 9 feet. Width 55 yards.

(h_2) Narrow zone of degraded *feo*, 12 yards wide, lagoonward of the *feo* similar to that on the seaward side.

(c) Moat, 40 yards wide and up to 1 foot deep at low water. The floor is bare rock with patches of gravel and numerous black holothurians; there are no growing corals (Plate 19).

(g) Intertidal conglomerate platform with small patches of mobile sand, drying at low water, and passing inland beneath the beach. 55 yards wide.

(e) Seaward beach face, 14 yards wide, sandy in its lower part, topped by coarser gravel, with a hedge of *Scaevola*, *Tournefortia* and *Guettarda*.

Profile 10

Peari, south shore, near the center of the island.

(a) *Porolithon* zone of knobby and paint-like algae. 40 yards wide from the wave-break line. Surge channels are present but are very narrow; they are spaced 4-5 yards apart.

(b) Orange zone. This zone is here narrow (14 yards wide) and undergoing active dissection.

(b_1) Inner part of the Orange Zone. Width 11 yards. This has a rough microtopography, with potholes up to 4.5 feet in diameter and 1.5 feet deep: the actual orange area (mainly on the rims) is thus much reduced.

(j) Zone of smooth exfoliating reef rock, 38 yards long, standing 2-3 feet above the Porolithon zone (Plates 22 and 23).

(k) Rock-floored moat, containing water at low tide, but without corals; width 30 yards.

(h_2) Zone of degraded feo 40 yards wide, similar to that in Profile 9.

(h) Feo: zone of elevated reef rock up to 9 feet high. Bare rock is exposed for a width of 54 yards: on the inner part there are scattered shrubs of Pemphis acidula growing directly on the rock.

(e) Seaward beach face, perched on the feo, with pinnacles of reef rock protruding through the beach sands. The beach is built of sand with some shingle and is 20 yards wide. On the face itself there are scattered Pemphis and Guettarda; and at the crest a hedge of Guettarda and Scaevola.

Profile 11

Ututo, south shore, center of the island.

(a) Porolithon zone, 35 yards wide, with closely spaced surge channels, similar to Profile 10.

(b) Orange zone, 21 yards wide, and at the same level as the inner Porolithon zone. Unusually the rims and potholes are absent, and instead there is a flat pavement, through which a few surge channels extend into zone (b_1).

(b_1) High fretted zone, separated from zone (b) by a scalloped clifflet 1 foot high: the surface is rough and eroded. 25 yards wide.

(j) Zone of smooth exfoliating reef rock. Doming is very pronounced, but at this point the zone is only 12 yards wide. Occasional reef blocks up to 4.5 feet high and 9 feet long are found along the reef edge.

(k) Rock-floored moat, with up to 1 foot of water at low tide, but with no living corals; width 40 yards.

(h_2) Strip of degraded feo 15 yards wide.

(h) High feo, 35 yards wide and up to 9 feet high, with scattered Pemphis acidula, passing landward under beach sands (Plates 26 and 27).

(e) Seaward beach face, perched on the feo, 35 yards wide, and rising to 13 feet above the flat. The beach is sandy, topped by incipient dunes, with a vegetation cover of Scaevola, Pandanus, Guettarda and coconuts.

V. PROBLEMS OF RANGIROA GEOMORPHOLOGY

A. Consolidated sediments

1. The problem of the Feo.

In the history of the surface features of Rangiroa, the problem of the nature and origin of the feo is crucial. The chief facts about the feo are as follows:

(1) It is restricted to the southern rim of the atoll, where it is reported to extend from at least Tehaare in the west to the eastern end of the southern rim, a distance of 44 miles: it is not found on the northern or western rims.

(2) It is restricted to a narrow band with a mean width of about 120 yards, situated on the outer part of the reef rim some 120 yards from the reef edge.

(3) The mean height of the upper part of the feo is 6-7 feet above the inner reef flat (approximate low water level), and the highest parts 10 feet.

(4) Since exposure, marine abrasion has formed lower erosional platforms up to 50 yards wide on the seaward side of the feo and up to 10 yards wide on the lagoon side.

(5) The main body of the feo has been eroded into a tough delicate tracery of spires and pinnacles. When struck with a hammer, the rock rings. In hand specimens the rock is so recrystallized as to be structureless.

The Rangiroa feo was described by Dana (1849, 75), who stated that "the reef stood eight feet or so out of water, and was worn into a range of columns, or excavated with caverns, so as to look very much broken, though quite regularly even in the level of the top line." Agassiz later described it as "a wall of old reef rock from 10 to 14 feet in height ... (which) varies in width from 250 to 500 feet" (1903, 45). Elsewhere he gives the height as "from 8 to 15 feet" (1903, 50), "12 to 14 feet" (1903, 16), and "15 to 16 feet" (1903, 20). Agassiz studied the feo at Fenuaroa, where

> "...the great wall of ancient elevated reef rock ... was fully 12 feet high, and is the remnant of the ancient coralliferous limestone ridge which flanked the southern side of Rangiroa. ... This old ledge is deeply pitted and honeycombed and eroded into all kinds of fantastic spires and pinnacles and walls cut through by crevasses extending from low-water mark to the summit, which is more or less covered by the high sand beach accumulated behind it on the lagoon side. This beach completely conceals the extension of the old ledge under the island" (1903, 46).

Recently Tercinier (1956, 39) published a section showing the feo outcropping near the seaward shore of an island and continuing lagoonward

beneath the island surface, well above sea level for the greater part of the width of the island.

The identification of the _feo_ as ancient elevated reef rock is probably correct. In hand-specimen characteristics and erosional features it is closely comparable to the rock of undoubted elevated reefs at New Georgia, Solomon Islands, where, however, similar erosional fretting only occurs in areas subject to salt spray (Stoddart, _in litt._) Agassiz's speculations that the _feo_ is a remnant of a previous atoll-wide or even archipelago-wide sheet of Tertiary limestone lacks evidence; and the suggestion by both Agassiz and Tercinier that the _feo_ underlies most of the island surfaces on the southern rim seems to be mistaken; Agassiz in particular wrongly identifies _feo_ and island conglomerate as the same. The _narrowness_ of the _feo_ is one of its most striking characteristics: approached from the lagoon side it presents a wall as steep as that on the seaward side. Hence it does not form a cuesta tilted lagoonward; and the small width of the abrasion platform on its lagoonward side demonstrates that its form has not been greatly modified by recent marine erosion. This narrowness, and its localization on the flat, together form the chief problem of the _feo_; no erosional mechanism seems to explain it adequately.

The second problem of the _feo_ is its restriction to the southern rim. Three alternative models may be proposed to account for this:

(1) _Feo_ formerly existed all around the atoll rim, as a result of relative movement of land and sea, but has since been entirely removed on the windward side by marine erosion. It is not possible to explain the complete absence of _feo_ on the west rim by this model, for apart from storms the west rim is the most protected side of the atoll.

(2) Slight local tilt of the atoll raised the southern rim: solution fretting, recrystallization and case-hardening of the emerged reef limestone was followed by marine abrasion on both seaward and lagoonward (_i.e._, windward) sides, before island clastics began to accumulate. Such local movement would explain the absence of _feo_ elsewhere on the rim; but the explanation of the narrowness of the _feo_ is strained. Observations in the Bahamas (Newell 1961) and the Solomons suggest that the amplitude of marine erosion of limestones is very limited.

(3) Regional tilting within the Tuamotu Archipelago. _Feo_ is reported elsewhere in the Tuamotus, particularly on the south side of the chain, as at Anaa, where the _feo_ reaches 18 feet (Newell 1956, 326), Kaukura (15 feet: Ranson 1962, 18), and other atolls. In other places, as at the intensively investigated Raroia, _feo_ is absent. The existence of _feo_ at different heights on several atolls, the localized distribution of _feo_ within individual atolls, and its nonoccurrence on others render unlikely a simple eustatic sea-level shift as an explanation of its origin. More data are required on the distribution of _feo_ in the Tuamotus before regional explanations can be accepted.

337-682 O-69—8

2. Problem of island or motu conglomerate.

Second to the problem of the feo is that of the origin of the sheets of conglomerate which underlie many of the islands and characteristically outcrop in the walls of every hoa. The relationship of these sheets and the feo, with reef-flat reef rock, and with beachrock require clarification. Wherever seen, the motu conglomerate consisted of worn coral fragments in a sandy matrix; it is a detrital rock, and is in no sense a reef rock which has suffered relative elevation. Agassiz is wrong when he states that this conglomerate, together with the feo, is "the remnant of a bed of tertiary coralliferous limestone which at one time covered the greater part of the area of the lagoon" (1903, 16; also 44); it is hard to see how he could have reached this conclusion. Ranson (1962) also mistakenly states that the conglomerate indicates a former higher sea level.

In no place was the conglomerate seen in contact with the feo. In the Peari-Vaihoa hoa conglomerate is found in the island walls only 53 yards from the feo wall (Plate 24). Conglomerate is intimately associated with islands: it is not found either seaward or lagoonward of the general width of the islands, except in places where recent shore erosion is reasonably inferred (Plates 3 and 11). This is strikingly shown in the hoa, where the island sediments have been eroded, leaving the underlying conglomerate (Plate 4). The conglomerate is formed of similar materials to the islands themselves, generally becoming finer lagoonward, and nowhere contains corals in the position of growth or indeed any sedimentary structures indicative of submarine deposition. On the west shore of Porahu the conglomerate stands up to 2 feet above sea level, and unconformably overlies an eroded reef surface, with truncated corals several feet in diameter standing about six inches above low water level (Plate 21). The elevation of the top of the conglomerate platform everywhere strikingly follows that of the island surfaces, being higher to seaward and declining gradually lagoonward. Typically its seaward edge forms a low cliff up to 3 feet high; lagoonward it falls to three feet or less.

The Rangiroa island conglomerate appears similar to that described by Newell at Raroia, where the pakaota is

> "clearly bioclastic throughout and does not contain in situ reef material. It is not an elevated platform of planation, a reef flat, but it is a depositional surface ... (which) could have been formed at or near the existing sea level" (Newell 1956, 332).

The formation of conglomerate platforms beneath islands and their subsequent exposure by erosion and shoreline migration, as outlined by Newell (1961, 103-4), appears adequately to explain all features of the Rangiroa conglomerate, though Newell does not discuss mechanism. The conglomerate is probably a water-table, calcite-cemented rock, forming beneath islands at the present time. Newell's excavations at Garumaoa, Raroia, failed to demonstrate incipient rock. At Rangiroa, however, an I.R.H.O. soil pit at Tepaetia, dug to a depth of 2 meters, wholly in coarse coral rubble, some of it apparently imbricate,

revealed that the top meter was uncemented, the next 80 cm moderately cemented, and the last 20 cm above the water table very well cemented. A pit dug at Tiputa during the construction of the schoolhouse also showed the following section:

0 - 1 meter	unconsolidated rubble
1 - 1 m 50	cemented rubble
1 m 50 - 2 m	unconsolidated rubble
2 m +	cemented rubble (at water table).

The widespread existence of the conglomerate platform beneath islands is shown by the surface sand stripping at Maeherehonae.

In topography and probably origin the Rangiroa conglomerate is similar to the cay sandstones (calcarenites rather than calcirudites) previously described in the Caribbean (Stoddart (1963, 108-110) and the Maldive Islands (Stoddart, Davies and Keith 1966).

3. Problems of beachrock.

A distinction is made here between the island conglomerate and beachrock, although the two are similar in lithology and often rather difficult to distinguish in the field. Beachrock is invariably found forming a strip 5-10 yards wide at the foot of seaward beaches, dipping seaward at 5-10° and even occasionally at up to 20°. It is usually a conglomerate with two or three layers, and overlies a smooth rock platform of similar composition and appearance but doubtful status which passes under the beach sediments. In the entrances to _hoa_, the stratigraphic distinction between seaward-dipping beachrock and the underlying planed reef flat is clear: but no satisfactory and crucial exposures were seen of the relationship between the beachrock and the island conglomerate. Beachrock is generally absent within the _hoa_ itself.

As at Raroia, relict beachrock is found, especially on the northern rim of Rangiroa, _e.g._, at Tiputa, trending at an angle to the present beach and isolated on the seaward reef flat, indicating recent retreat of the shoreline. Very little fresh beachrock was seen, and much was quite heavily eroded. Almost no beachrock was seen on lagoon shores (one case was seen at Tivaru), perhaps because these are generally prograding. The horizontal outcrops of rock found on many lagoon shores up to 2 feet above low water level, as at Mahereretiatae, Tepaetia and Tiputa, are all island conglomerate rather than beachrock (Plate 7).

4. Other lithified sediments at Rangiroa.

Phosphate rock was seen underlying raw humus within 40 yards of the shore at Porahu, on the southern rim of the atoll. It is here disturbed by human activity and is on the site of an old settlement. Phosphate is also reported from Putehue, Ahorehore and Tepau, on the southern rim, and at Maufano at the eastern end of the atoll. According to M. Pomier, _Pisonia grandis_ is present at, or has recently been cleared from all of these locations. Further study is needed of the

nature of the phosphate, its vegetational associations, and its apparent restriction to the southern rim [and east end--Ed.] at Rangiroa.

Cemented horizons in the sand dunes at Maeherehonae add a fifth type of lithified material at Rangiroa. These are probably associated with local water tables in the dunes, are thin and friable, and, unusually at Rangiroa, are calcarenites.

B. Surface features of the seaward reef flats

There are broad similarities between all the seaward reef flats at Rangiroa. The flat itself is a rock-floored feature, sloping gradually from the seaward shores of the islands towards the raised rim. Growing corals are everywhere scarce, even in the deeper seaward section, and there is only an intermittent and thin cover of mobile sand and gravel. The growth of small algae gives the submerged floor a pink color, in contrast to the higher inner part, often drying at low water, which is dark brown. The higher, more exposed parts of the flat often show truncated corals in section, together with coral branches weathering out: the flat is clearly erosional, deriving from a previously higher level. The strength of longitudinal water currents produced by water pouring over the rim in the process of draining out suggests that lowering is still in progress. No parts of the reef flat as here defined rise more than a few inches above low water level.

The raised rim at the seaward edge of the flat (Guilcher and others 1966) is a problematical feature. It corresponds in location and in general form with the Lithothamnion or algal ridge described from other Pacific atolls. Living pink algae are restricted, however, to the outer face of the rim, which slopes seaward at about 5° and is furrowed by surge channels. This is normally 30-50 yards wide. The rest of the rim, of a similar width, has been here termed the Orange Zone, because of the distinctive color given to it by algal growth. The topography of the Orange Zone is quite clearly erosional (Plates 9 and 10): it is furrowed by grooves and cut by potholes, often leaving only a tracery of curving sharp ridges. The inner, landward-facing edge of the Orange Zone, locally rising 2-3 feet above the reef flat floor, is clearly being cut back by erosion, giving a grooved and scalloped pattern in plan. The rock underlying the Orange Zone, where sampled, appears to contain more recrystallized coral than algal material. In places coral fragments are recognizable in the weathering patterns. This is, therefore, not a true algal ridge, at least as this term is understood in the Pacific literature: it is rather a relict rim of reef rock, which has been colonized and presumably added to on its seaward side by pink algae, at the same time undergoing continuous erosion on its upper surface and inner edge by marine action. The upper part of the Orange Zone currently lies too high for colonization by pink algae. On this interpretation, the origin of the abrupt break of slope between the ridge and the reef flat floor is of interest: presumably solution and mechanical erosion are deepening the flat and cutting back the rim from land to sea, and as the flat is itself deepened the break of slope forms automatically.

On the southern rim a further feature of interest is the zone of exfoliating reef rock (Plates 22 and 23) tens of yards in width between the Orange Zone and the feo, from which it is separated by a moat. The phenomenon of exfoliation in reef limestones does not seem to have been closely studied: here it is striking, and has the appearance of an exfoliating igneous rock. Tentatively, it may be interpreted as part of the slightly raised reef rock not yet removed by marine erosion: the difference between northern and southern rims being the result of the greater exposure and hence more rapid erosion on the former.

The similarity of surface features of the seaward flats implies a common history, and the widespread evidence of vertical erosion calls for a fairly recent slight negative shift in the relative level of land and sea.

Other surface features of the reefs were not closely investigated. Surge channels were found, passing seaward into spur-groove systems, on all sides of the atoll, though developed most strongly on the northern side, where the reef front is also said to slope more steeply than on the south. Newell found spur-groove systems around the whole atoll perimeter at Raroia also. The great variation in development of lagoon reefs, between the narrow fringe on the northern rim (facing leeward) and the 200-300 yard wide platforms on the west and south rims (facing windward) is also noteworthy. Similar variations are described from some of the Marshall Island atolls (Emery, Tracey and Ladd 1954).

C. Unconsolidated sediments

The unconsolidated sediments of the islands at Rangiroa are overwhelmingly coarse. On the northern rim coral shingle is dominant across the whole width of islands, while elsewhere on the rim shingle forms the seaward beaches and the seaward part of the island surface. On the beach face itself the material is generally fresh, white in color, and fine, with longest dimensions of less than 6 inches; but on the beach crest, especially on the north side, the longest dimension of the rough blackened coral blocks is commonly greater than 12 inches. No more detailed observations were made on shingle-caliber material. Sand-size sediments are restricted on the northern rim to pockets of sand along the seaward beach, often sheltered by outcrops of beachrock, and also along the lagoon beach. Elsewhere on the atoll rim the lagoon beach of islands and the lagoonward part of the island surface is dominantly sandy, with patches of shingle. Nine sand samples were taken from the seaward and lagoonward beaches of Tiputa on the northern rim. Median diameter ([Ø16+Ø50+Ø84]/3) varied from -1.18Ø (very fine gravel) to +1.05Ø (medium sand), and averaged +0.48Ø. All samples had a high foraminiferal content: the coarsest sands are dominated by a white discoid foram, and the fine ones by a small brown foram which gives the sand a distinct color cast. Sorting (σ_I = [Ø84+Ø16]/4 + [Ø95+Ø5]/6.6) is moderately good (0.45 to 0.90 Ø), averaging 0.75.

D. Tentative geomorphic history of Rangiroa

Evidence for the reconstruction of the geomorphic history of Rangiroa is sparse, and much detailed work remains to be done. Agassiz, for example, reports many data from the islands in the lagoon which, if confirmed, would materially affect a geomorphic chronology. Because many of his observations and interpretations are doubtful, this section attempts to place only my own observations into logical order. The observations reported here clearly do not do justice to the complexity of so large an atoll, and on many aspects of atoll geomorphology, such as the lagoon floor and submarine topography, we have virtually no data at all. There is need not only for the checking of Agassiz's observations but for the extension of those reported in this paper.

The early history of the Tuamotu atolls on the Darwin Rise is at present largely conjectural: there is no reason to doubt the applicability of Darwin's own subsidence model, which was in fact being formulated as he sailed through the Tuamotus in 1835 (Darwin 1962). Deep drilling at Mururoa Atoll in the Southeast Tuamotus has revealed a basalt substrate to coral limestone at depths of 438 and 415 meters, clearly demonstrating subsidence (Lalou and others 1966, Chauveau and others 1967): presumably Rangiroa similarly was formed and achieved its present plan through the Tertiary. Subsequent history based on known geology and geomorphology may be summarized as follows:

(1) The first event to affect the present surface feature of the atoll was the formation and exposure of the feo. The distribution of feo on the atoll and through the archipelago suggests that its uplift was caused by tilting of regional extent but of locally variable amplitude. Exposure was followed by case-hardening and recrystallization of the limestones, marine abrasion of the margins, and the beginning of superficial salt-spray solution. The total uplift at Rangiroa cannot have been greatly in excess of 10 feet. Veeh (1965, 53; 1966) has recently published uranium-series dates on elevated reef limestones from Anaa Atoll, Tuamotus, standing 2-4 meters above mean low tide land, which range from 80,000 to 150,000 years. However, dating of the cores from Mururoa Atoll has revealed a major discontinuity at -20 meters, below which the limestone ages are greater than 500,000 years, and at -6 meters, overlying limestones 100,000 ± 10,000 years old. Limestones above -6 meters, have ages of less than 5,000 years. The lower discontinuity is referred to the penultimate interglacial, and the higher to the last interglacial; the higher correlates in depth and age with that described from Eniwetok in the Marshall Islands (Thurber and others 1965). The emerged feo dated at 80,000 years by Veeh may thus correlate with the last interglacial discontinuity found in cores and dated at 100,000 years: if so, it would form an uneroded residual blanketted by recent (less than 5,000 years) reef limestones.

(2) Following the exposure of the feo, which in extent of lithification and erosion is probably the oldest rock on Rangiroa, the reef rim of the atoll was exposed, more or less uniformly, by a relative change in level of land and sea. This resulted in the

formation of raised reef flats up to about 2 feet, perhaps less, above low water. After elevation, planation by marine erosion began, and has proceeded farthest on the windward side. Here rock-floored flats have been cut below present low water level, leaving residual edge rims now partly coated with pink algae. On the leeward side, large areas of slightly raised exfoliating reef rock remain. Radiometric dating has been used at Mururoa to argue for a post-glacial high stand of the sea reaching +4 meters (12 feet) at 3,000 years B.P., which could account for the high reef-flats at Rangiroa (Lalou and others 1966).

(3) Island formation has taken place, probably following the erosion of the elevated flats to present levels, though evidence here is sparse. Some sediments may have accumulated before the flats were raised, but there is certainly no sign of elevated reef rock surviving under the present islands, though as Newell has pointed out, it would be unwise to assume that reef flats are necessarily underlain by reef rock in the narrow sense. Detrital islands probably formed a nearly continuous chain around the windward rim of the atoll, except for the deep passes, and also along much of the southern rim. With the accumulation of sediments, there followed the formation of plates of conglomerate rock at island water tables.

(4) The phase of aggradation has been followed by one of erosion, resulting in the retreat of seaward beaches, exposing beachrock and leaving patches of relict beachrock on seaward reef flats, and in the cutting of numerous hoa and the fragmentation of formerly continuous land. This is documented by the extent of island conglomerate between islands. It might be possible to argue that hoa formation and closure is a continuing process, and that as one hoa is being cut another is being filled. If this were so, stages (3) and (4) could be synchronous. However, eroding hoa are so common, and infilling hoa so rare (only one was seen at Mahereretiatae) that the inference of successive occurrence is thought to be justified. No detailed attempt can be made to link these observed changes with known Pleistocene events, though data from Mururoa is suggestive. It should be noted that the evidence for changes in level used here is not that used by Agassiz; and that the evidence which he used to demonstrate sea-level changes, *i.e.*, the island conglomerate, is here used as evidence of recent stability.

There seems to be no simple and satisfactory explanation of the narrowness of reef flats and concentration of land on the windward side of the atoll, and the width of the flat and the relative absence of land on the leeward side. Newell's explanation of a similar situation at Raroia, that the strength of the southern swell sending a continuous sheet of water over the leeward flat prevented the accumulation of debris (Newell 1956, 330), clearly will not hold at Rangiroa, where such a mechanism is inhibited by the feo. Sediment production may be relatively greater on the windward side, where continuous erosion also limits the width of the flat.

NOTES ON LAND VEGETATION OF RANGIROA

On uncultivated islands the dominant vegetation is Guettarda forest extending from the backslope of the seaward ridge to the lagoon beach. On the seaward beach crest Suriana maritima is everywhere dominant in the most exposed situations, with Pemphis acidula much less common; Scaevola is absent in such situations. In some places (Mahereretiatae, Tepaetia) wind-trimmed clumps of Tournefortia and Hedyotis are found near the beach crest itself. The main vegetation hedge, situated on the backslope some distance landward of the seaward beach crest, consists of Guettarda and Tournefortia, with occasional Pandanus, and often much Cassytha. On the lagoon beach Suriana is again dominant, growing low on the beach; Pemphis is seen only rarely (e.g., Tivaru, Mahereretiatae). Immediately landward there is tall Tournefortia and Guettarda (Porahu, Tivaru), and sometimes low Scaevola (Tepaetia, Tivaru). In the Guettarda woodlands, Morinda citrifolia is not abundant, and trees normally associated with settlement are rare. The flora is a small one, and the number of important species very few. The importance of Suriana maritima is surprising compared with its role in the Caribbean and the Maldives; and so is the unimportance of Scaevola (an unusually small variety) compared with its importance in the Maldives and the Melanesian area.

On cultivated islands the basic pattern is much the same, but the Guettarda forest has been replaced by coconut plantations, there are many introduced weeds, and also numbers of cultivated and decorative plants in the villages. On the seaward ridges Suriana maritima is dominant, with some Pemphis; and between the beach and the plantation there is invariably a dense thicket of Tournefortia and Guettarda, with occasional Pandanus. In the coconut plantation both Guettarda speciosa and Morinda citrifolia are common (including many juveniles): there is a ground cover of Stachytarpheta, Cassytha, ferns and Lepturus, and occasional low bushes of Scaevola. The most striking undergrowth beneath the coconuts, however, is Euphorbia atoto, growing at least to heights of 3 feet, and on Avatoru to more than 6 feet. The lagoon beach again has Suriana and Tournefortia.

In the villages of Tiputa and Avatoru there are tall trees of Cordia subcordata, Hibiscus tiliaceus, Casuarina and Coccoloba along the shore, with Hibiscus rosa-sinensis, frangipani, Carica papaya and Artocarpus lining the streets. In the taro pits, root crops such as Colocasia, Xanthosoma and Cyrtosperma are no longer grown; breadfruit, bananas and melons are grown instead. Tacca was also formerly cultivated, but was not seen. Limes are grown but are not common.

Several habitats have distinctive vegetation, and may be briefly noted. On the feo, at Peari and Utoto, Pemphis acidula is dominant, with a little Suriana. On stripped island conglomerate surfaces, at Maeherehonae and in the Moao-Hararu gap, there is a sparse vegetation dominated by Pemphis, together with Suriana and Hedyotis: with very infrequently Tournefortia and even rare Morinda, Guettarda and Scaevola. In the hoa between islands, both Pemphis and Suriana line the edges of channels, often growing directly on the rock surface. Around the margins of pools near the lagoon shores of islands sedges are common: at

Avatoru and Tereiao there is a dense belt of *Cladium*. On the sand dunes of Maeherehonae vegetation is restricted to *Pandanus* and *Tournefortia*. Ottino (1965, 9) points out that old settlement sites may often be recognized by the concentration there of *Pandanus*, *Hibiscus tiliaceus*, *Casuarina*, *Calophyllum* and *Cordia*.

There is a marked absence at Rangiroa of a pioneer strand vegetation comparable to the *Sesuvium-Ipomoea* strand vegetation of the Caribbean; *Ipomoea* was not seen at all; and the pioneer seems to be a shrub, *Suriana maritima*.

REFERENCES

Agassiz, A. 1903. The coral reefs of the tropical Pacific. Memoirs of the Museum of Comparative Zoology, Harvard College, 28: 1-410. 3 volumes of plates.

Aubert de la Rüe, E., 1964. Remarques sur les atolls de l'archipel des Tuamotu (Polynésie Française). Bulletin des Laboratoires de Géologie, Minéralogie, Géophysique et du Musée géologique de l'Université de Lausanne, 151: 1-18.

Chauveau, J.-C., G. Deneufbourg and J. A. Sarcia. 1967. Observations sur l'infrastructure de l'atoll de Mururoa (Archipel des Touamotou, Pacifique Sud.) Comptes rendus, Académie des Sciences, Paris, 265(D): 1113-1116.

Dana, J. D. 1849. Geology. U. S. Exploring Expedition during the years 1838-1842, under the command of Charles Wilkes USN. Philadelphia, 750 p. Atlas of 21 plates.

Danielsson, B. 1954. Raroian culture. Atoll Research Bulletin 32: 1-109.

__________. 1956. Work and life on Raroia: an acculturation study from the Tuamotu Group, French Oceania. London, 244 p.

Darwin, C. R. 1962. Coral islands. Atoll Research Bulletin 88: 1-20.

Doty, M. S. and J. P. E. Morrison. 1954. Interrelationships of the organisms on Raroia aside from man. Atoll Research Bulletin 35: 1-61.

__________, J. Newhouse, H. A. Miller, and K. Wilson, 1954. Floristics and plant ecology of Raroia atoll. Atoll Research Bulletin 33: 1-58.

Emery, K. O., J. I. Tracey, Jr., and H. S. Ladd. 1954. Geology of Bikini and nearby atolls. U. S. Geological Survey, Professional Paper 260-A: 1-265.

Fosberg, F. R. 1956. Military geography of the Northern Marshalls. Intelligence Division, Office of the Engineer, Headquarters U.S. Armed Forces Far East and Eighth States Army. 320 p.

Garanger, J. and A. Lavondès. 1966. Recherches archéologiques à Rangiroa, archipel des Tuamotu. Journal de la Société des Océanistes, 22: 25-66.

Geographical Handbook Series. 1943. Pacific Islands, Volume II, Eastern Pacific. London, Naval Intelligence Division. 739 p.

Guilcher, A., M. Denizot, and L. Berthois. 1966. Sur la constitution de la crête externe de l'atoll de Mopelia ou Maupihaa (Iles de la Société) et de quelques autres récifs voisins. Cahier Océanographiques, 18: 851-856.

Harry, R. R. 1953. Ichthyological field data of Raroia Atoll, Tuamotu Archipelago. Atoll Research Bulletin 18: 1-190.

Lalou, C., J. Labeyrie, and G. Delibrias. 1966. Datation des calcaires coralliens de l'atoll de Mururoa (archipel des Tuamotu) de l'époque actuelle jusqu'à -500,000 ans. Comptes Rendus Académie des Sciences, Paris, 263(D): 1946-1949.

Newell, N. D., 1954a. Expedition to Raroia, Tuamotus. Atoll Research Bulletin 31: 1-23.

_________. 1954b. Reefs and sedimentary processes of Raroia. Atoll Research Bulletin 36: 1-35.

_________. 1956. Geological reconnaissance of Raroia (Kon Tiki) Atoll, Tuamotu Archipelago. Bulletin, American Museum of Natural History, 109: 311-372.

_________. 1961. Recent terraces of tropical limestone shores. Zeitschrift für Geomorphologie, Supplementband 3: 87-106.

Ottino, P. 1965. Ethno-histoire de Rangiroa. Publication provisoire. Papeete, Centre Orstom de Papeete. 167 p.

Menard, H. W. 1964. Marine geology of the Pacific. New York. 271 p.

Morrison, J. P. E. 1954. Animal ecology of Raroia Atoll. Atoll Research Bulletin 34: 1-26.

Ranson, G. 1962. Mission dans le Pacifique: récifs coralliens, huîtres perlières. Paris. 100 p.

Stoddart, D. R. 1963. Effects of Hurricane Hattie on the British Honduras reefs and cays, October 30-31, 1961. Atoll Research Bulletin 95: 1-142.

Stoddart, D. R. 1965. The shape of atolls. Marine Geology, 3: 369-383.

__________. in litt. Marine Geology of New Georgia, British Solomon Islands.

Stoddart, D. R., P. S. Davies, and A. C. Keith. 1966. Geomorphology of Addu Atoll. In Stoddart, D. R., editor, Reef studies at Addu Atoll, Maldive Islands. Atoll Research Bulletin 116: 13-41.

Tercinier, G. 1956. Contribution à l'étude des sols coralliens des atolls (Les sols de Rangiroa: Tuamotou). VIe Congrès International de la Science du Sol, Paris, V, 6: 37-42.

Thurber, D. L., W. S. Broecker, R. L. Blanchard and W. A. Potratz. 1965. Uranium-series ages of Pacific Atoll coral. Science, 149: 55-58.

Veeh, W. W. 1965. Thorium -230/uranium -238 and Uranium -234/Uranium-238 ages of elevated Pleistocene coral reefs and their geological implications. University of California at San Diego, Ph.D. thesis, I-XII, 1-91.

__________. 1966. Th^{230}/U^{238} and U^{234}/U^{238} ages of Pleistocene high sea land stand. Journal of Geophysical Research, 71: 3379-3386.

Wiens, H. J. 1962. Atoll environment and ecology. New Haven and London. 532 p.

LIST OF VASCULAR FLORA OF RANGIROA

by Marie-Hélène Sachet

Botanists from various expeditions through the South Pacific have on occasion collected a few plants on Rangiroa, as for instance W. B. Jones of the Whitney Expedition which stopped for two days in August 1922, and E. H. Quayle in 1923. These plants are reported on by F. B. H. and E. D. W. Brown in the Flora of Southeastern Polynesia (Bishop Museum Bulletins 84: 1931, 89: 1931, 130: 1935). However, no intensive investigation of the flora has ever been made. In 1963 I was invited to spend a week at the coconut research station of the IRHO (Institut de Recherches pour les Huiles et Oléagineux) in order to make some botanical observations and a collection of plants for the use of the station. The director of the station, M. Pomier showed me various parts of the atoll. His help and hospitality made the visit very profitable and enjoyable and I am glad to express my appreciation to him and to the IRHO.

One set of the plants collected was left at Tiputa for ready reference, and one at the Department of Agriculture of Tahiti. Other sets are intended for the Muséum d'Histoire Naturelle in Paris, B. P. Bishop Museum in Honolulu and U. S. National Museum.

The 70 specimens collected, as well as some sight records, are listed below, with brief notes on occurrence. The determinations were verified by F. R. Fosberg. An asterisk * before a name indicates that the species is not indigenous in Rangiroa. Synonyms are given only when they have been widely used in the area.

PSILOTACEAE

PSILOTUM NUDUM (L.) Beauv.
Tepaetia islet, locally abundant at base of coconut palm and shrubs, Sachet 1356.

POLYPODIACEAE

ASPLENIUM NIDUS L.
Porahu islet, common locally in shady *Guettarda* forest, Sachet 1384.

NEPHROLEPIS BISERRATA (Schwartz) Schott
Porahu islet, common locally in tall *Guettarda* forest, in shade, Sachet 1382.

POLYPODIUM SCOLOPENDRIA Burm. f.
Tiputa village, very common everywhere on ground, Sachet 1344.

PANDANACEAE

PANDANUS TECTORIUS Park.
Common over much of atoll; spineless variety seen in Tiputa village.

GRAMINEAE

*CENCHRUS ECHINATUS L.
Tiputa village, common locally in weedy area back of village, Sachet 1375.

*CYNODON DACTYLON (L.) Pers.
Tiputa village, forming lawn; very common, Sachet 1350.

DIGITARIA STENOTAPHRODES (Nees) Stapf.
Avea islet, occasional on bare gravel in area cleared for planting of coconut palms, Sachet 1378.

*ELEUSINE INDICA (L.) Gaertn.
Tiputa village, common in weedy area back of village, Sachet 1371.

*ERAGROSTIS PILOSA Beauv.
Tiputa village, very abundant in weedy area back of village, Sachet 1370.

LEPTURUS REPENS var. REPENS (Forst. f.) R. Br.
Tepaetia islet, tufts at top of ocean beachridge, Sachet 1360.

PASPALUM DISTICHUM L.
P. vaginatum Sw.
Avatoru islet, Avatoru village, forming wide zone in weedy area around pond, Sachet 1385.

*SACCHARUM OFFICINARUM L.
Tiputa, a few plants seen in village.

*SPOROBOLUS AFRICANUS (Poir.) Rob. & Tourn.
Avatoru village, weed in village, common, Sachet 1389.

CYPERACEAE

CLADIUM JAMAICENSE Crantz
Avatoru village, forming dense patches at edge of marshy area around pond, Sachet 1386. This plant has yellowish achenes varying from ovoid to ellipsoid, and from 2 to 2.5 mm in length. It does not fit either var. *chinense* (Nees) Koy. or var. *jamaicense*, but exactly connects the two.

CYPERUS JAVANICUS Houtt.
Tiputa village, common locally in low area in weedy area back of village, Sachet 1374.

*CYPERUS KYLLINGIA Endl.
Tiputa village, common weed in village, Sachet 1395.

*CYPERUS POLYSTACHYOS Rottb.
Tiputa village, occasional along road in weedy area back of village, Sachet 1373.

*CYPERUS ROTUNDUS L.
Tiputa village, occasional weed in lawns, Sachet 1402.

FIMBRISTYLIS CYMOSA R. Br.
Avatoru village, occasional on dry ground at edge of marshy area, Sachet 1387. This collection has compact, button-like heads, styles with either 2 or 3 branches, predominantly 3, achenes mostly trigonous, smooth.

PALMAE

*COCOS NUCIFERA L.
Planted over most of atoll.

*Unidentified palm, possibly *Caryota* sp.
Planted.

COMMELINACEAE

*COMMELINA sp.
Tiputa, seen in village.

*RHOEO SPATHACEA (SW.) Stearn
Avatoru, cultivated in village.

LILIACEAE

*CORDYLINE FRUTICOSA (L.) Goepp.
Porahu, persisting in former inhabited site.

AMARYLLIDACEAE

*CRINUM sp.
Tiputa, seen in village.

*ZEPHYRANTHES ROSEA (Spreng.) Lindl.
Tiputa, planted in village.

DIOSCOREACEAE

*DIOSCOREA BULBIFERA L.
Porahu islet, occasional in shady forest, Sachet 1383, probably remaining from cultivation.

TACCACEAE

TACCA LEONTOPETALOIDES (L.) O. Ktze.
Tiputa village, occasional in abandoned yards and in plantation, Sachet 1341.

MUSACEAE

*MUSA sp.
Tiputa, planted in village.

CANNACEAE

*CANNA sp.
Tiputa, planted in village.

CASUARINACEAE

*CASUARINA EQUISETIFOLIA L.
Tiputa, planted in village.

MORACEAE

*ARTOCARPUS ALTILIS (Park.) Fosb.
Tiputa, Avatoru, planted in villages.

URTICACEAE

LAPORTEA RUDERALIS (Forst.) Chew
Fleurya ruderalis (Forst.) Gaud. ex Wedd.
Vahituri islet, common in open areas in coconut plantation, Sachet 1397.

PIPTURUS ARGENTEUS (Forst.) Wedd.
Tiputa village, occasional in scrub forest between village and ocean, Sachet 1367.

POLYGONACEAE

*ANTIGONON LEPTOPUS W. & A.
Tiputa, cultivated in village.

*COCCOLOBA UVIFERA L.
Tiputa village, planted in village, Sachet 1334.

NYCTAGINACEAE

BOERHAVIA TETRANDRA Forst.
Tepaetia islet, occasional in coconut plantation, Sachet 1358; Vahituri islet, common in open areas in coconut plantation, Sachet 1398; Paitia islet, occasional in open coconut plantation, Sachet 1401.

*MIRABILIS JALAPA L.
Tiputa, planted in village and escaped.

PISONIA GRANDIS R. Br.
Paitia islet, a few trees left in scrub forest, Sachet 1400; Kaorafara islet, small grove in center of islet, Sachet 1399.

AMARANTHACEAE

ACHYRANTHES CANESCENS R. Br.
Moore 204 (US)

PORTULACACEAE

PORTULACA JOHNII v. Poelln.
Peari islet, common on sandy ground in open coconut plantation, Sachet 1381. Known previously from the Tuamotus, Austral Is., and Christmas Island. This species, in habit resembling *P. oleracea* L. but with the flowers, "open around 10 a.m. till 2 or 3 p.m."; stamens "30-40"; seeds more or less glossy, with interdigitating star-shaped, slightly raised tesselae.

LAURACEAE

CASSYTHA FILIFORMIS L.
Tiputa village, abundant locally climbing over shrub in scrub forest between village and ocean, Sachet 1366.

CRUCIFERAE

LEPIDIUM BIDENTATUM Montin
Tiputa village, common locally in weedy area back of village, Sachet 1372.

337-682 O-69—9

CRASSULACEAE

*KALANCHOE PINNATA (Lam.) Pers.
Tiputa, seen in village.

LEGUMINOSAE

*CASSIA OCCIDENTALIS L.
Avatoru, seen in village.

*DESMODIUM TRIFLORUM (L.) DC.
Utoto, seen in cleared coconut plantation.

*INOCARPUS EDULIS (Park.) Fosb.
Kaorofara, one seen persisting.

*LEUCAENA LEUCOCEPHALA (Lam.) deWit
L. glauca of authors, non (L.) Benth.
Tepaetia islet, one shrub seen in scrub, Sachet 1355.

*MIMOSA PUDICA L.
Utoto, Tuhere Pari, small patches seen in holes filled with soil from Tahiti.

SESBANIA SPECIOSA var. TUAMOTENSIS F. Brown
Avea islet, one clump seen (occasional on other islets) in area cleared for planting of coconut palms, Sachet 1380.

*VIGNA MARINA (Burm.) Merr.
Tuhere Pari, a few chlorotic vines seen in hole filled with soil from Tahiti.

RUTACEAE

*CITRUS AURANTIFOLIA (Christm.) Swingle
Tiputa, in village; Porahu islet, persisting, several flourishing trees.

*CITRUS sp.
Tiputa, one tree of "pamplemousse" seen in village.

SURIANACEAE

SURIANA MARITIMA L.
Tiputa village, abundant, forming strip at edge of scrub forest at top of ocean beach ridge, Sachet 1376.

EUPHORBIACEAE

*ACALYPHA spp.

Tiputa, several forms (red-leaved, green-and-white-leaved and frilled) cultivated in village.

EUPHORBIA ATOTO Forst.
Tiputa village, Sachet 1333; very abundant everywhere.

*EUPHORBIA HIRTA L.
Avatoru village, very common weed in village, Sachet 1390.

*EUPHORBIA PROSTRATA Ait.
Avatoru village, common locally as weed in village, Sachet 1391.

*EUPHORBIA sp.
Tiputa, succulent Euphorbia seen in village.

*PEDILANTHUS TITHYMALOIDES (L.) Poit.
Tiputa, planted in village.

*PHYLLANTHUS AMARUS Schum. & Thonn.
Tiputa village, common weed in yards, Sachet 1346, and in plantation.

*RICINUS COMMUNIS L.
Tiputa, planted in village.

ANACARDIACEAE

*MANGIFERA INDICA L.
Tiputa, 2 small trees planted at east end of village.

SAPINDACEAE

*POMETIA PINNATA Forst.
Tiputa, planted in village.

VITACEAE

*VITIS sp.
Tiputa, planted in village.

TILIACEAE

*MUNTINGIA CALABURA L.
Tiputa, planted as street tree, very abundant.

TRIUMFETTA PROCUMBENS Forst.
Tiputa village, abundant in ground-cover in scrub forest between village and ocean, Sachet 1365.

MALVACEAE

ABUTILON ASIATICUM var. ALBESCENS (Miq.) Fosb.
Tiputa village, weed in abandoned area, Sachet 1337.

*GOSSYPIUM sp.
Avatoru, seen in village.

HIBISCUS TILIACEUS L.
Tiputa village, common locally in scrub forest between village and ocean, Sachet 1369.

*HIBISCUS, ornamental hybrids
Tiputa, Avatoru, planted in villages.

*MALVASTRUM COROMANDELIANUM (L.) Garcke
Tiputa village, common locally in abandoned yards, Sachet 1352.

*MALVAVISCUS sp.
Tiputa, planted in village.

*SIDA RHOMBIFOLIA L.
Avatoru village, weed in village, common, Sachet 1388.

THESPESIA POPULNEA (L.) Sol. ex Correa
Tiputa, Kaorofara, planted or persisting.

BOMBACACEAE

*CEIBA PENTANDRA (L.) Gaertn.
Avatoru, seen in village.

STERCULIACEAE

*WALTHERIA INDICA L.
Tiputa village, occasional weed in plantation and yards, Sachet 1339.

GUTTIFERAE

CALOPHYLLUM INOPHYLLUM L.
Tiputa village, only a few trees seen, perhaps planted, in scrub forest between village and ocean, Sachet 1368.

CARICACEAE

*CARICA PAPAYA L.
Tiputa, planted in village, often in foundations of ruined houses.

PASSIFLORACEAE

*PASSIFLORA FOETIDA L. var. FOETIDA

Tiputa village, common weed in abandoned garden, Sachet 1335, also in plantation. The typical variety of *P. foetida*, widespread in the Caribbean and South America has previously not been reported from the Pacific Islands. The varieties known from there are var. *hispida* and var. *gossypifolia*. The present material, because of its long, yellow scarcely glandular stem pubescene, seems closer to var. *foetida* than to var. *gossypifolia*. Its non-interlaced, non-matted involucral bracts distinguish it from var. *hispida*.

LYTHRACEAE

PEMPHIS ACIDULA Forst.

Tiputa village, occasional (common elsewhere) in scrub forest at top of ocean beach ridge, Sachet 1377.

COMBRETACEAE

*TERMINALIA sp.

Tiputa, planted in village.

MYRTACEAE

*EUGENIA CUMINI L.

Tiputa, large tree planted in village.

*PSIDIUM sp.

Tiputa, Avatoru, seen in village; Porahu islet, persisting.

CACTACEAE

*OPUNTIA sp.

Tiputa, seen in village.

ARALIACEAE

*BRASSAIA ACTINOPHYLLA Endl.

Tiputa, planted in village.

*POLYSCIAS spp.

Tiputa, several species planted in village.

APOCYNACEAE

*ALLAMANDA sp.

Tiputa, planted in village.

*CATHARANTHUS ROSEUS (L.) G. Don
Tiputa village, Sachet 1340, common escaped from cultivation.

*NERIUM sp.
Tiputa, planted in village.

*PLUMERIA RUBRA L.
Tiputa, planted in village.

ASCLEPIADACEAE

*ASCLEPIAS CURASSAVICA L.
Avatoru, seen in village.

CONVOLVULACEAE

*IPOMOEA BATATAS (L.) Lam.
Tiputa, planted in village, in foundations of ruined houses.

*IPOMOEA OBSCURA (L.) Ker.
Tiputa village, weed in yard, Sachet 1353.

IPOMOEA TUBA (Schlecht.) Don
Porahu, in mixed scrub on lagoon side.

BORAGINACEAE

CORDIA SUBCORDATA Lam.
Tiputa village, planted in village, Sachet 1396.

HELIOTROPIUM ANOMALUM H. & A. var. ANOMALUM
Avea islet, occasional on bare sand, forming wide patch in area cleared for planting of coconut palms, Sachet 1379.

TOURNEFORTIA ARGENTEA L.f.
Tiputa village, common in scrub forest between village and ocean, Sachet 1363.

VERBENACEAE

*LANTANA CAMARA var. ACULEATA (L.) Moldenke
Tepaetia islet, a few plants seen in scrub, Sachet 1359.

NESOGENES EUPHRASIOIDES (H. & A.) A. DC.
Tepaetia islet, locally abundant in scrub, Sachet 1361.

*STACHYTARPHETA URTICIFOLIA Sims
Tiputa village, occasional weed in abandoned yards, Sachet 1347.

LABIATAE

*OCIMUM BASILICUM L.
Avatoru village, occasional in village, probably escaped from cultivation, Sachet 1392.

*OCIMUM sp.
Tiputa, some dried-up plants seen in village.

SOLANACEAE

*CESTRUM DIURNUM L.
Tiputa village, planted in garden, Sachet 1336.

*DATURA METEL L.
Tiputa village, a few plants escaped from cultivation, Sachet 1342.

SCROPHULARIACEAE

*RUSSELIA EQUISETIFORMIS L.
Avatoru, cultivated in village.

ACANTHACEAE

*PSEUDERANTHEMUM CARRUTHERSII var. ATROPURPUREUM (Bull) Fosb.
Tiputa village, planted in village, Sachet 1393.

RUBIACEAE

*GARDENIA TAITENSIS DC.
Tiputa, cultivated in village.

GUETTARDA SPECIOSA L.
Tiputa village, abundant in scrub forest between village and ocean, Sachet 1364.

HEDYOTIS ROMANZOFFIENSIS (C. & S.) Fosb.
Tepaetia islet, only a few plants seen in scrub, Sachet 1357.

*IXORA spp.
Tiputa, several species planted in village.

MORINDA CITRIFOLIA L.
Tiputa village -- Sachet 1338, common in scrub around village.

*PENTAS LANCEOLATA (Forsk.) Schum.
Tiputa village -- Sachet 1362, planted.

TIMONIUS POLYGAMA Forst.
Tiputa village, very common in scrub around village and in plantation, Sachet 1343 (staminate), 1348 (pistillate).

GOODENIACEAE

SCAEVOLA TACCADA var. TUAMOTUENSIS St. John
S. sericea Vahl, commonly misidentified as S. frutescens (Mill.) Krause.
Tiputa village, very common in scrub and in plantations, Sachet 1345.

COMPOSITAE

*BIDENS PILOSA L.
Tiputa village, occasional in yards and on roadside, Sachet 1349.

*ELEPHANTOPUS SPICATUS HBK.
Tiputa, seen in village.

*EMILIA JAVANICA (Burm.f.) C. B. Rob.
Tiputa village, occasional weed in roadside, Sachet 1354.

*SYNEDRELLA NODIFLORA (L.) Gaertn.
Tiputa village, weed in village, Sachet 1394.

*VERNONIA CINEREA var. PARVIFLORA (Bl.) DC.
Tiputa village, occasional weed, Sachet 1351.

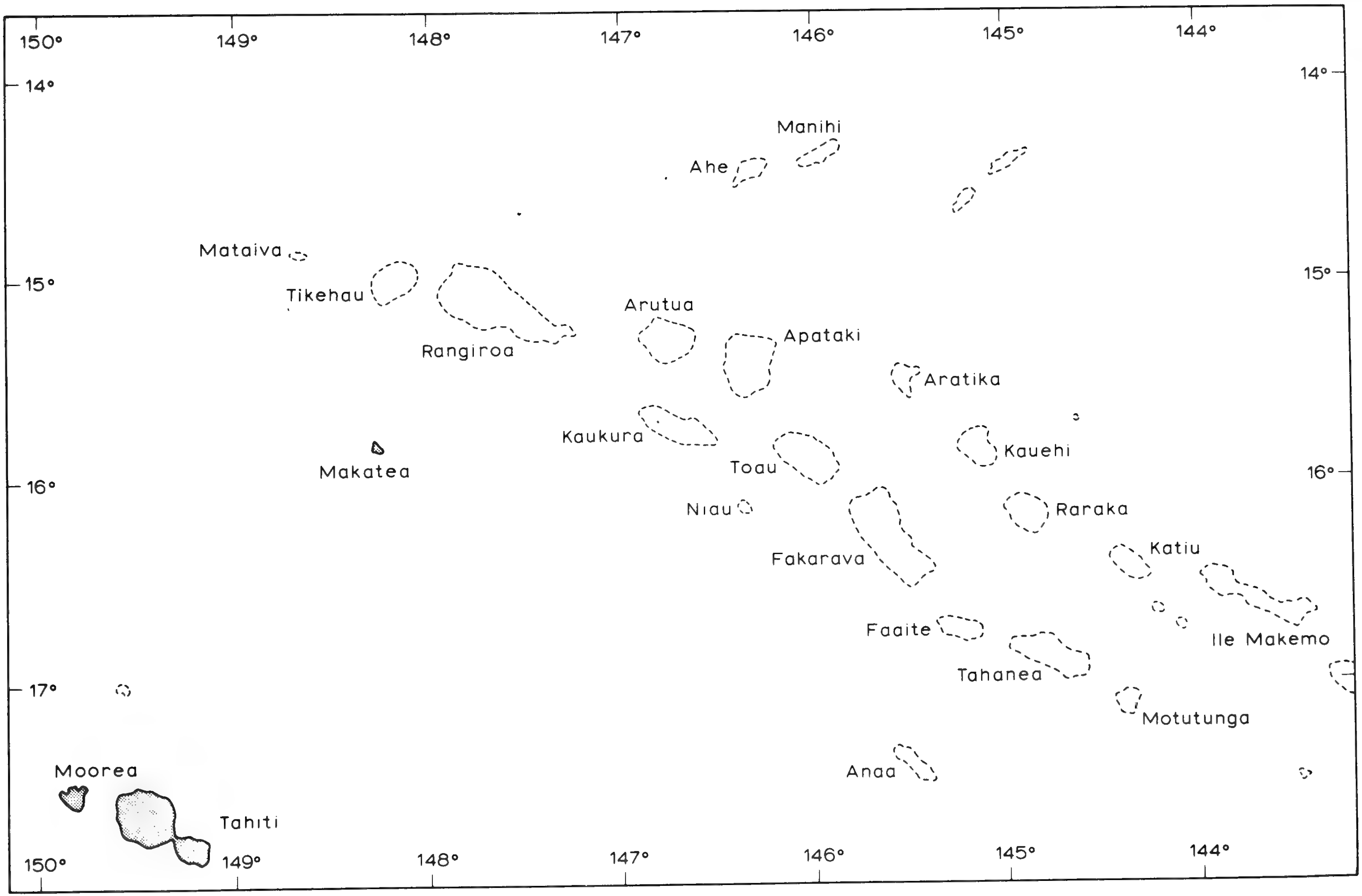


Fig. 1 Location of Rangiroa Atoll

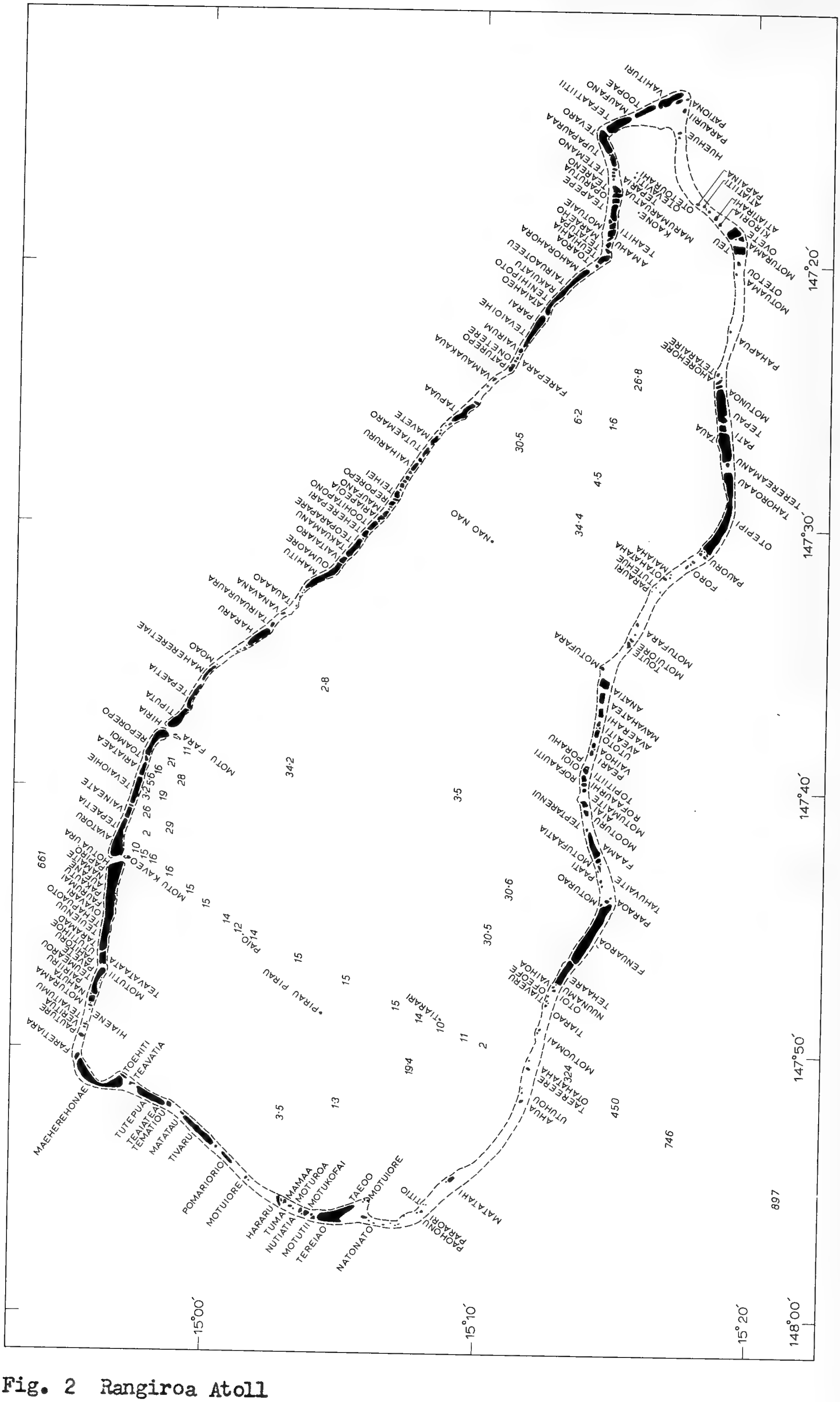


Fig. 2 Rangiroa Atoll

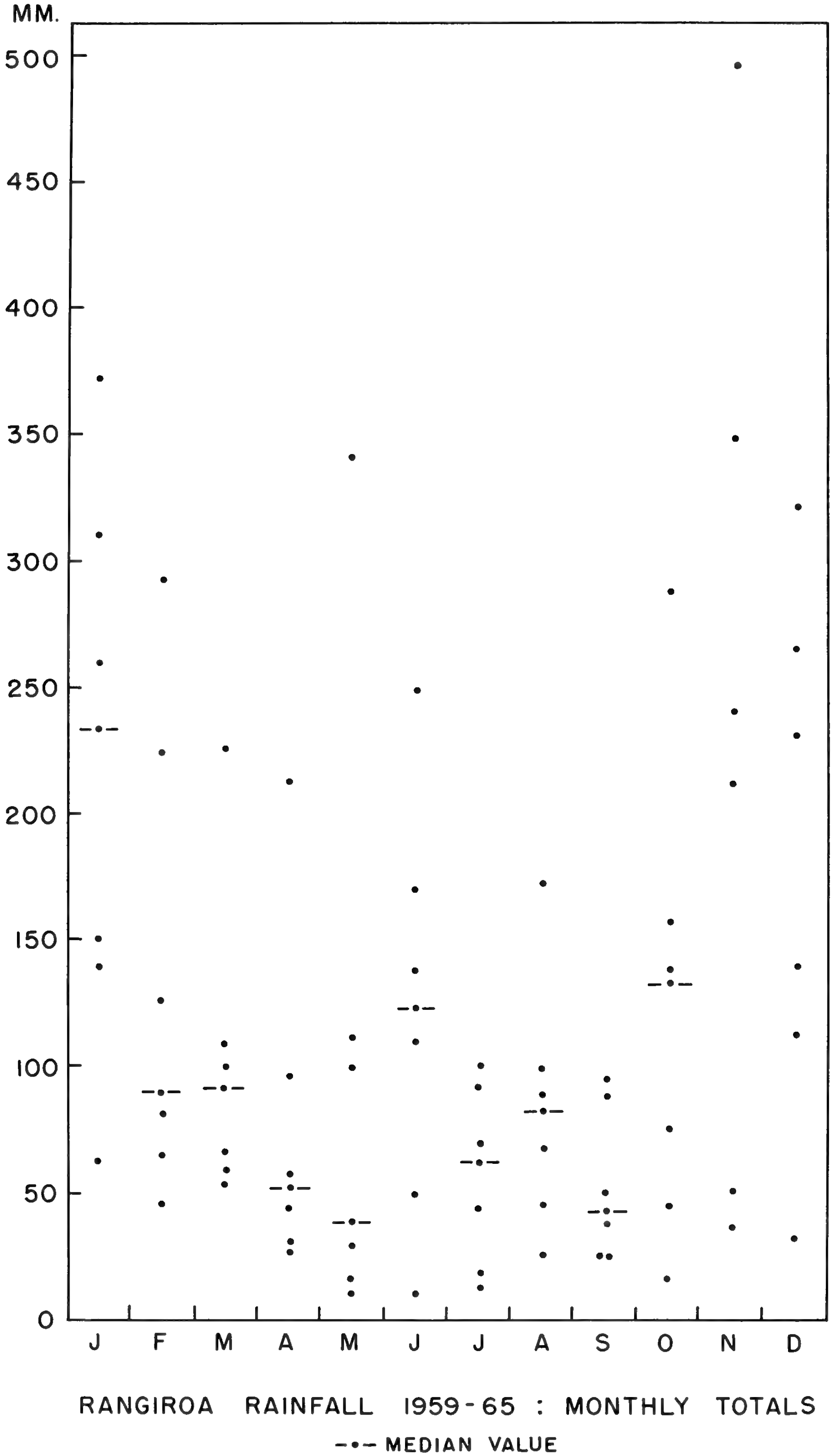


Fig. 3 Rangiroa rainfall 1959-65: monthly totals

RANGIROA RAINFALL 1960-65 : SINGLE DAY MAXIMUM FALLS IN EACH MONTH OF EACH YEAR OVER PERIOD OF RECORD.

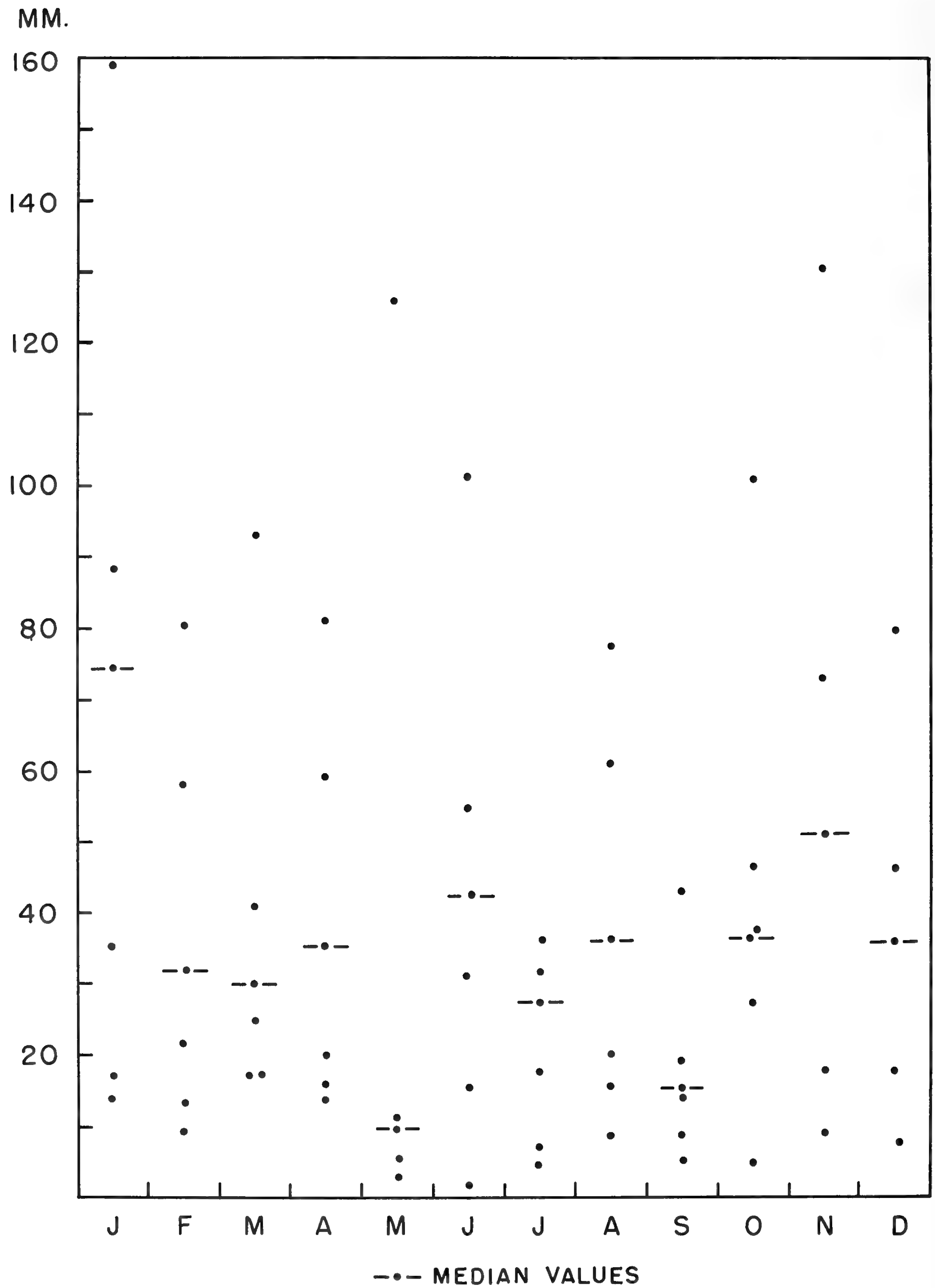


Fig. 4 Rangiroa rainfall 1960-65: single-day maxima

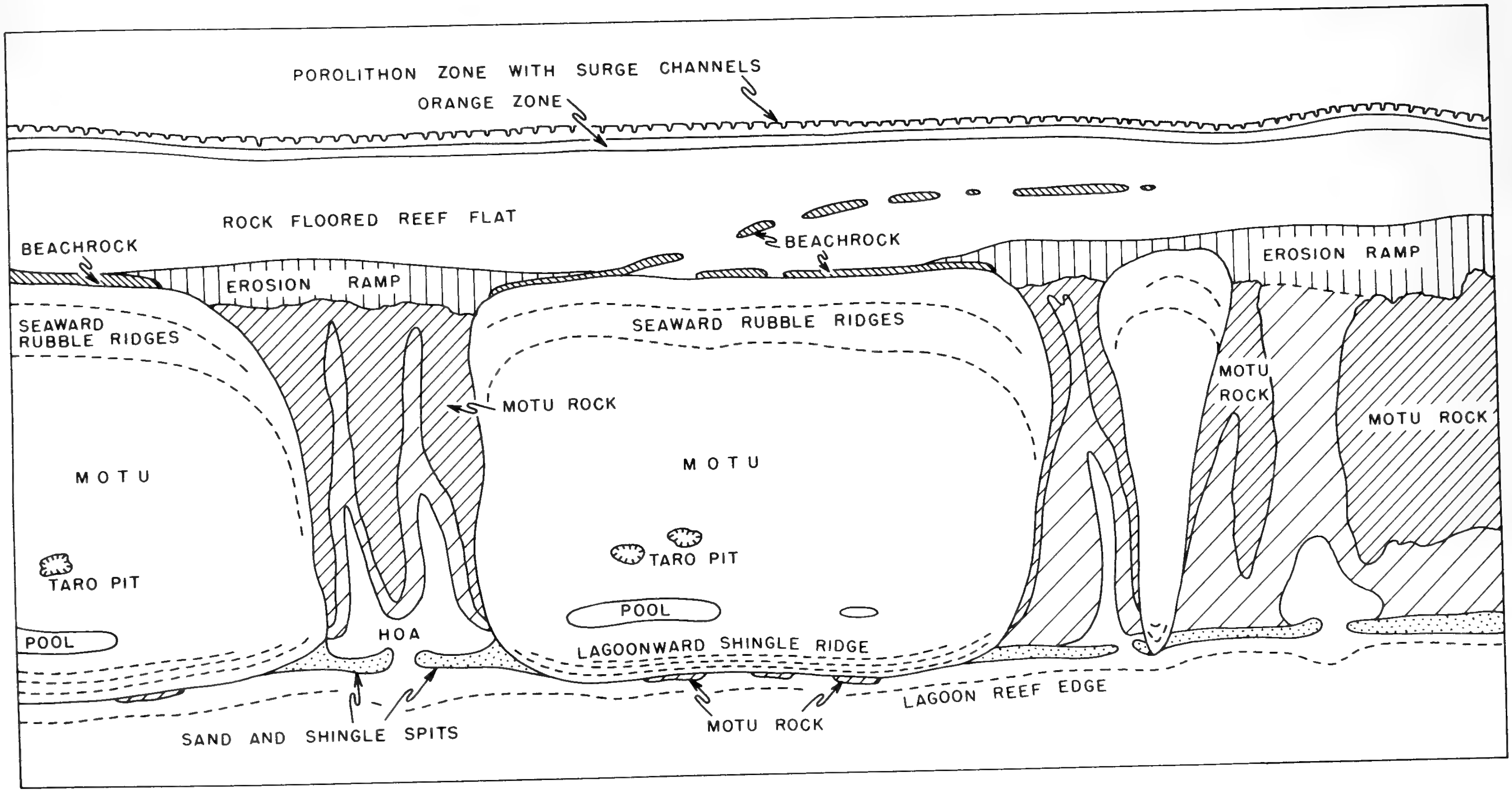


Fig. 5 Schematic diagram of northern rim with islands

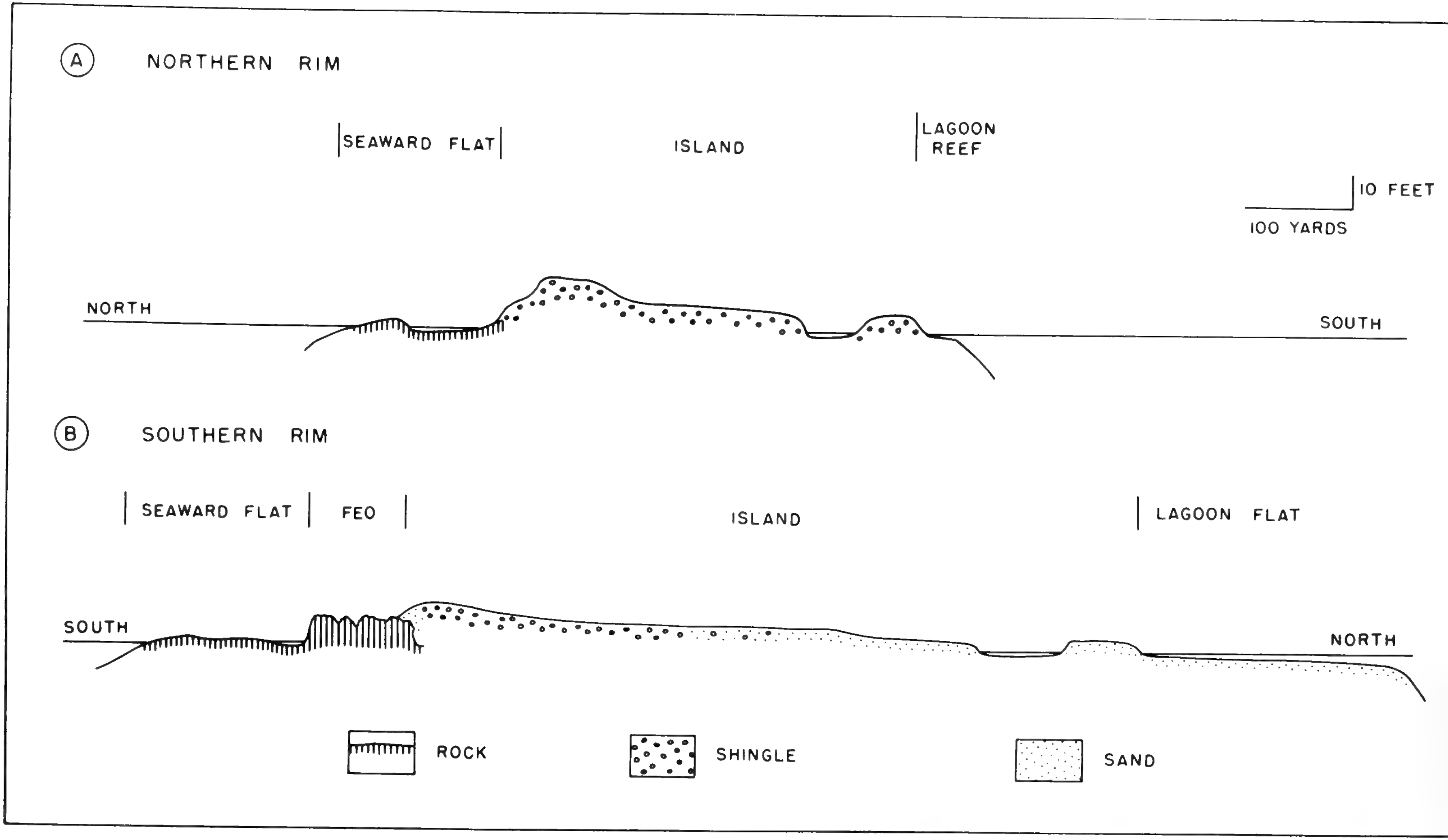


Fig. 6 Schematic sections of islands on north and south rims

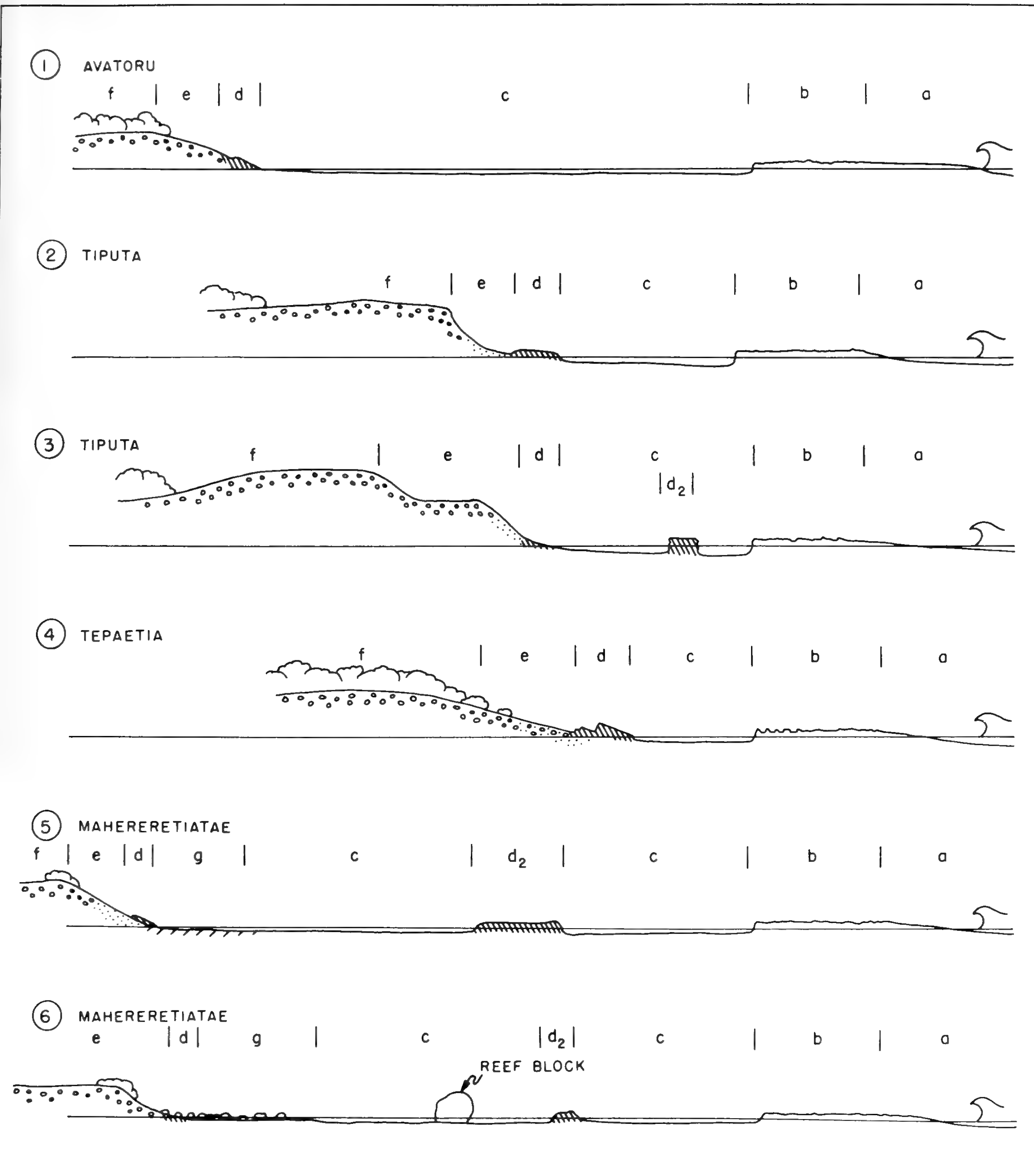


Fig. 7 Profiles 1-6, northern rim

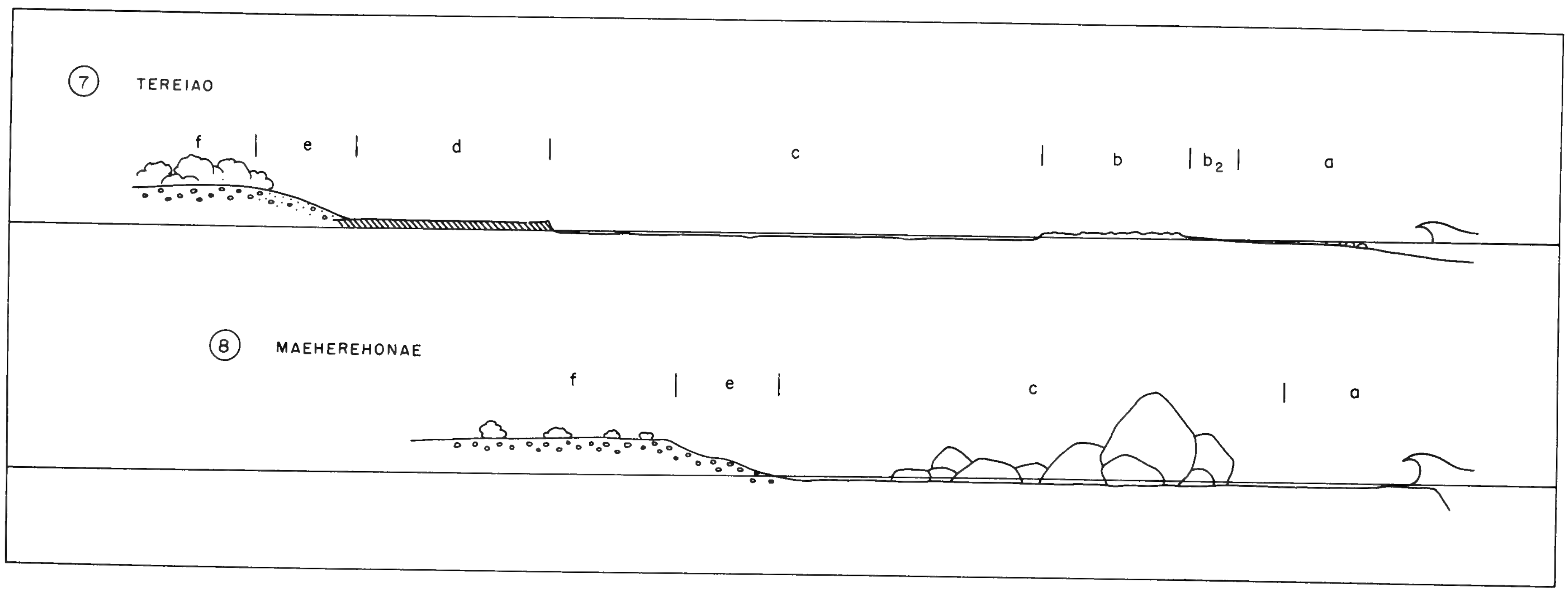


Fig. 8 Profiles 7-8, western rim

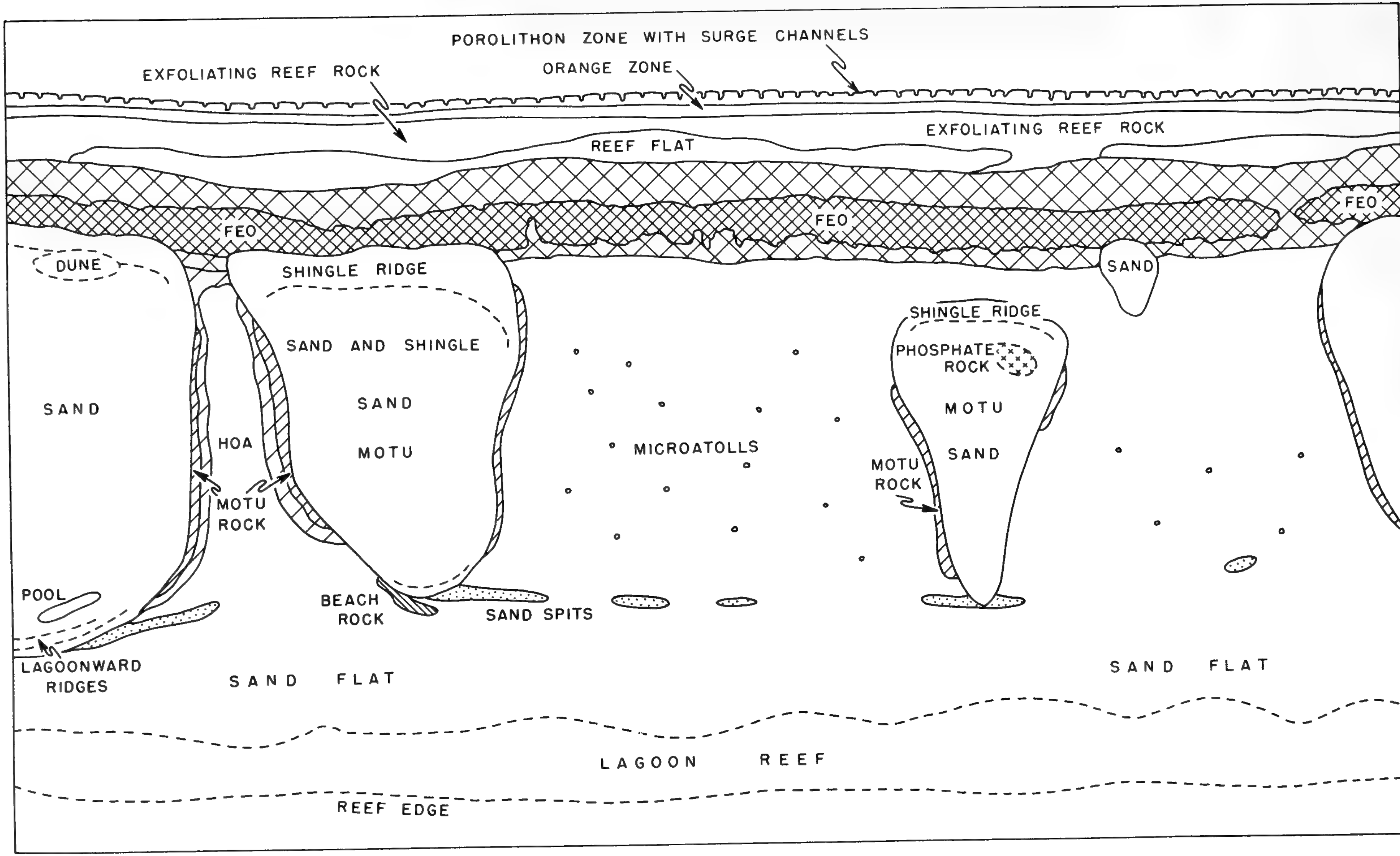


Fig. 9 Schematic diagram of southern rim with islands

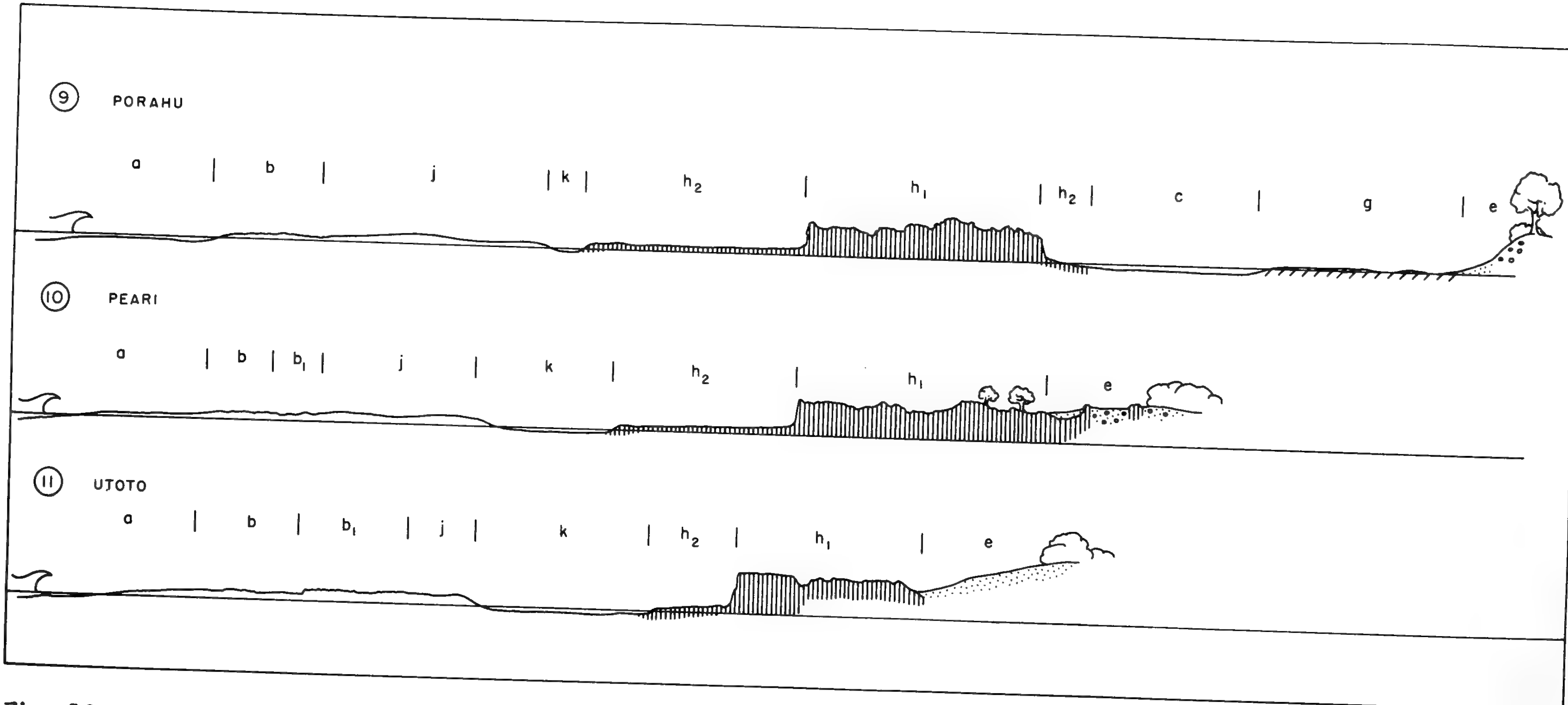


Fig. 10 Profiles 9-11, southern rim

1 Tiputa, north shore: seaward shingle ridge, smooth erosion ramp, and beachrock and rubble. Relict beachrock on reef flat in background.

2 Tiputa, north shore, west end, looking towards Reporepo: steep shingle beach, erosion ramp, and conglomerate beachrock.

3 Tiputa, north shore: shingle beach with massive beach-foot conglomeratic beachrock. Note the narrowness of the reef flat.

4 Tiputa-Tepaetia hoa: view from the lagoonward end, on Tiputa, towards the seaward reef.

5 Tiputa, north shore: beach-crest vegetation hedge of Tournefortia and Hedyotis, showing defoliation, with coconut palms.

6 Tiputa, south shore, east end, looking westwards: low sandy lagoon beach with coconut plantation.

7 Tepaetia, south shore, west end, near entrance to hoa: outcrop of island conglomerate on a sandy beach. Note the absence of a lagoon reef.

8 Avatoru: marécage at west end of the island, looking north.

9 Tepaetia, north shore, east end, view east: edge of seaward reef flat at low water: pink algal zone on the left (covered with water), dissected orange zone in the center; drying reef flat to the right.

10 Tereiao, west shore, view south: edge of seaward reef flat at low water: dissected pink algal zone.

11 Tereiao: massive conglomerate at the foot of the seaward beach.

12 Tereiao: fresh coral shingle on the crest of the seaward beach.

13 Tereiao: lagoon-side marécage with Cladium.

14 Maeherehonae: large lagoon-side marécage with sandy lagoonward sand strip in the foreground.

15 Maeherehonae: view towards the lagoon from the summit of the dunes, across the marécage. Pemphis, Pandanus and coconuts in the foreground.

16 Maeherehonae: a recently-excavated marae on top of the lagoon-side dunes.

17 Maeherehonae: conglomerate platform, with Pemphis acidula, at water-level between the dunes.

18 Maeherehonae, west shore, northern end: storm blocks on the seaward reef flat, photographed from the seaward beach. Note the human figure on the largest block.

19 Porahu, seaward shore: feo separated by a narrow moat from the seaward shore of the island.

20 Porahu: islandward margin of the feo shown in Plate 19. Note the narrow basal erosion platform.

21 Porahu, west shore: island conglomerate unconformably overlying truncated reef corals. Seaward feo in the background.

22 Peari: seaward reef edge with exfoliating reef rock on the reef flat.

23 Peari: exfoliating reef rock on the seaward reef flat.

24 Peari-Baihoa <u>hoa</u>: island conglomerate outcropping in the <u>hoa</u> walls with seaward <u>feo</u> in the background.

25 Vaihoa-Tuoto hoa: small sand cay with Pandanus perched against the seaward feo.

26 Utoto: feo with Pemphis and perched beach, looking eastwards.

27 Utoto: dissected seaward margin of the feo.

ATOLL RESEARCH BULLETIN

No. 126

ISLAND NEWS AND COMMENT

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D. C., U. S. A.

March 30, 1969

337-682 O-69—11

ISLAND NEWS AND COMMENT

To be more in keeping with our broadened scope, to include islands, generally, rather than only atolls, we make the above change in title for this feature of ARB. We hope our readers will continue to send in news items, short original observations and ideas, and publications (or brief reviews of publications) pertaining to islands. In this issue we may have omitted some items that should have been included. If so we hope that we will be excused. We have just made a catastrophic move to less satisfactory quarters, and many things have not yet come to the surface. We hope to be better organized shortly, and also to be more prompt with future issues. The timing of appearance of issues is dependent on receipt of satisfactory manuscripts, as well as on our efficiency or lack thereof.

News

INDIAN OCEAN ATOLLS: Aldabra Expedition: The Royal Society Expedition to Aldabra was landed on the Island by HMS Vidal August 13, 1967, has continued in the field to the present, and is planned to go on for an indefinite period, in phases of about three months each. Some change of personnel has taken place with each phase, but some members have stayed on for two or even three phases. The aim is to get scientific coverage as broad as possible.

The threat to establish an air staging post by the Royal Air Force, aided by the U.S. Air Force was, at least temporarily, abated shortly after the devaluation of the British pound in November 1967. Dropping this foolish and expensive plan resulted in substantial savings to both the British and U.S. taxpayers and in the preservation for continued scientific study of a remarkable and uniquely interesting set of biological phenomena.

It is the hope of the Royal Society to establish a small permanent scientific station on the island, with several field camps at strategic points around the 60-mile oblong of the atoll. It will make possible the long-term studies that may lead to far more than the usual superficial understanding resulting from short and hurried visits. As a first step toward this end the present expedition is trying to amass as complete an inventory as possible of the biota and the physical features of the ecosystem. In addition, behavioral studies of some of the conspicuous animals have been started.

To the end of phase 3 there have been a geomorphologist, a malacologist, an ichthyologist, a marine ecologist, two algologists, a fresh-water biologist, four herpetologists, three ornithologists, three

entomologists, two mangrove ecologists, two vascular plant botanists, and a conservationist as members of the expedition, as well as several supporting personnel.

An enormous amount of data and vast collections of specimens have been gathered, and much more activity is planned for future phases of the expedition, after phase 5 which is in the field at present. It is hoped to bring together these substantial bodies of information in a special volume of the Philosophical Transactions of the Royal Society next year. Preliminary notes, tentative and incomplete observations and discussion may appear in the future numbers of the ARB.

Assumption, Astove, Cosmoledo: Short visits to Assumption, Astove, and Cosmoledo atolls were made by personnel of the Aldabra Expedition. Collections of plants, birds, and insects were made to the extent possible in one-day visits, and observations on many features of the islands were recorded. On Astove the new lessees of the island, Veevers-Carter and his family were courteous hosts and supplied much information about the island and their plans for developing it.

It is hoped that a future issue of the ARB can be devoted to the results of these visits. These three islands are slightly elevated atolls similar to Aldabra but much disturbed by phosphate mining.

The following list of participants has been furnished by Dr. David R. Stoddart, of the Royal Society Aldabra Committee:

As plans are made to extend the Royal Society Expedition to Aldabra into its second year, more than thirty scientists will have participated by the end of August 1968. The following list covers personnel from Phases I (August-September 1967), II (October-December 1967), and III (January-March 1968), with some indication of the fields covered by each.

Dr. D. R. Stoddart (leader), Department of Geography, Downing Place, Cambridge, England: August-September 1966 and August-September 1967. Geomorphology and collections of plants during the dry season.

J. F. Peake, Department of Zoology, British Museum (Natural History), Cromwell Road, London, S.W.7.: September 1967. Land mollusca.

Dr. J. Morton Boyd, The Nature Conservancy, 12 Hope Terrace, Edinburgh, Scotland: September 1967. Conservation studies.

J. H. Price, Department of Botany, British Museum (Natural History), Cromwell Road, London, S.W.7.: September 1967. Marine algae, particularly algal distribution along transects at West Island.

C. F. Rhyne, Department of Botany, Smithsonian Institution, Washington, D.C. 20560, U.S.A.: August-September 1967. Collection of marine algae, and also lichens.

Dr. H. A. Fehlmann, Oceanographic Sorting Center, Smithsonian Institution, Washington, D.C. 20560, U.S.A.: August-September 1967. Marine fish.

C. W. Benson, Department of Zoology, Downing Street, Cambridge, England: September 1967 and January-April 1968. Land birds.

Dr. J. D. Taylor (field leader, Phase II), Department of Palaeontology, British Museum (Natural History), Cromwell Road, London, S.W.7. Intertidal ecology, with special reference to mollusca but with attention to corals, algae, crustacea and other groups.

M. J. Penny, Department of Zoology, University of Bristol, Bristol (address c/o The Wildfowl Trust, Slimbridge, Gloucestershire, England): August-December 1967. Shore birds.

A. W. Diamond, Department of Zoology, University of Aberdeen, Aberdeen, Scotland: September 1967 - April 1968. Sea birds.

P. Grubb, Zoological Society of London, address c/o Department of Zoology, University College, Gower Street, London, W.C.1: September 1967 - April 1968. Population studies of the Giant Land Tortoise.

Dr. K. G. McKenzie (field leader, Phase III), Department of Zoology, British Museum (Natural History), Cromwell Road, London, S.W.7: January-April 1968. Hydrology and fauna of the freshwater and brackish pools.

J. Frazier, Department of Zoology, University of Oxford, Oxford, England: January-July 1968. Behavioral studies of the Giant Land Tortoise.

Dr. F. R. Fosberg, Smithsonian Institution, U.S. National Museum, Washington, D.C. 20560, U.S.A.: January-February 1968. Vegetation and flora.

S. A. Renvoize, Royal Botanic Gardens, Kew, Richmond, Surrey, England: January-April 1968. Vegetation and flora.

Dr. W. MacNae and N. I. Passmore, Department of Zoology, University of the Witwatersrand, Jan Smuts Avenue, Johannesburg, South Africa: January-February 1968. Mangrove biota.

B. H. Cogan and A. M. Hutson, Department of Entomology, British Museum (Natural History), Cromwell Road, London, S.W.7: January-April 1968. Insects.

Dr. J. C. Shaffer, Department of Entomology, Smithsonian Institution, Washington, D.C. 20560, U.S.A.: January-April 1968. Insects, especially Lepidoptera.

A list of personnel from Phases IV, V and VI (April 1968 - February 1969) will be published in the next issue of ARB.

PLANT COLLECTION ON WESTERN INDIAN OCEAN ATOLLS: Drs. David Wood and M. D. Gwynne visited many of the atolls in the Seychelles, Amirantes, and Aldabra groups in November 1967, on the M. V. Manihine, of the EAMFRO (see below). Somewhat over 400 collections of plants were made, under the auspices of the East African Herbarium, where the principal set will be deposited, as well as a set at Kew. A list of these will be published in a future number of ARB.

CHRISTMAS ISLAND (INDIAN OCEAN): Dr. Bryan Nelson, formerly of the University of Aberdeen, has recently returned from several months ornithological work on the elevated limestone island of Christmas Island, eastern Indian Ocean. Christmas is the last known nesting place of Abbott's Booby, *Sula abbotti*, first described from Assumption Island near Aldabra. Nelson's book, *Galapagos, Islands of Birds* (London: Longmans, 1968, 338 pages, fifty shillings), though not about atolls, contains a great deal of useful information on the behavior of the Red-footed Booby, the Frigate-birds, and other common tropical oceanic sea birds, much of it not readily available elsewhere.

CLIPPERTON ISLAND: A small permanent station was established on Clipperton by the French Navy in 1966. In addition to continuing meteorological data collection, observations on the hydrology of the lagoon and on the flora and especially fauna of the atoll have been carried out during several expeditions, mostly by French Navy physicians, and some results assembled in mimeographed reports of the "Division de Biologie générale et Ecologie" of the "Centre de Recherches du Service de Santé des Armées". These reports are mostly preliminary in nature and of very limited distribution, but we hope to include some of the results on the fauna and hydrology in a future issue of ARB.

RENNELL AND BELLONA ISLANDS: John Grover, Director of the Geological Survey Department of the British Solomon Islands since 1950, has now left to take up a similar post in Fiji. During his work in the Solomons, visits were made to the elevated atolls of Rennell and Bellona, south of Guadalcanal. Rennell has become reasonably well known from the work of the *Noona Dan* Expedition, and Grover has also written a short account of it ('Rennell--the great uplifted atoll on the edge of the Coral Sea', *Geol. Surv. Brit. Solomon Islands Memoir* 2, 1958, 134-139). Much less was known of Bellona until recently. Grover published a short report on 'The discovery of phosphate rock on Bellona Island, 1956' (*Geol. Surv. Brit. Solomon Islands Memoir* 2, 1958, 120-134), which stimulated further work. Two papers appeared in the *Brit. Solomon Islands Geol. Record*, 1, 1960: 'Rennell Island--prospecting for phosphates, 1957', pp. 42-43, and 'Bellona Island--further prospecting for phosphate 1957, and a brief description of geological features', pp. 44-53, by P. A. Pudsey-Dawson and J. H. Hill, respectively. Volume 2 of the *Geological Record*, published in 1965, contains two further papers: 'Survey of phosphate deposits in the southwest Pacific and Australian waters--Bellona Island', by W. C. White and O. N. Warin, pp. 72-84, and 'Extracts from a report on the investigations of phosphate deposits on Bellona Island', by T. A. Adams, pp. 85-88. The publications of the Solomon Islands Survey are available from the Department of Geological Surveys, Honiara, B.S.I.P.; Crown Agents,

4 Millbank, London, S.W.1. (up to 1960); or Her Majesty's Stationery Office, Kingsway, London (1965). Dr. Torben Wolff has published a very useful guide to the work of the Noona Dan expedition, including that on Rennell ('The Noona Dan Expedition 1961-1962, General Report and Lists of Stations', Vidensk. Medd. fra Dansk naturh. Foren., 129, 1966, 287-336); this paper lists the expedition's publications to date.

The above listed exploration reports, though marking a great increase in our knowledge of two of the more interesting islands in the Pacific, may be taken as a prophesy of disaster for them. The discovery of commercial quantities of phosphate on an island has yet to spell anything but destruction for the ecosystem concerned. Even where the islanders have shared in the profits of the phosphate enterprise, this has merely enabled them to leave their homes after conditions had become intolerable.

BIKINI ATOLL: According to a recent announcement from the White House, Bikini is now considered again safe for human habitation, and plans are under way to permit the Bikini people to return from Kili Island to Bikini. It is said that the coconut crabs still retain enough Strontium-90 in their shells to pose some radiation hazard, and that measures will have to be taken to eliminate them. This would be a very foolish thing to do, at least until work was done to determine just what age groups are radioactive, whether the flesh is so as well as the shells, and whether there is any concentration taking place from the present very low level of soil radioactivity. Plans are even being considered to cover the major islands with a layer of coral rock "to reduce further the low level of radiation from the soil". It is to be hoped that before this is done the coral rock used will, itself, be tested for radioactivity.

BRITISH HONDURAS ATOLLS: Through the courtesy of the Rev. Leonard E. Dieckman, S.J., of Belize, we are able to note the drilling of two holes, one on Turneffe Atoll, the other on Glover's Reef, by the Belize Shell Development Co. in 1966 and early 1967. The Turneffe hole went through 4000 feet of reef limestone, then 200 feet of boulder clay, then to a depth of 7000 feet through clay, to a diorite basement. The Glover's Reef hole reached basement at 3147 feet. The object of the drilling was, of course, oil, but none was found. It is hoped that the cores or cuttings will be preserved and made available for study.

R. V. MANIHINE: It may be of interest to those concerned with work in the western Indian Ocean islands that the research vessel Manihine, a motor ship 118 feet long and 208 tons displacement, is available for oceanographic and biological investigations, operating out of Mombasa, Kenya. The vessel is owned by the East African Marine Fisheries Organization (EAMFRO), headquarters in Zanzibar, and operated for them by Southern Lines, Inc., Mombasa.

The Manihine has a fair-sized biological laboratory, a small hydrology laboratory, and two cabins for 5 scientists, 2 bunks in one, 3 in the other. It is equipped with freezers, 2 echo-sounders, a bathythermograph, deep-water sampling equipment, and appropriate winches, as well as the gear for studying pelagic fisheries.

It makes frequent cruises and interested and qualified scientists are invited to make use of it.

Inquiries may be addressed to the director of EAMFRO, Mr. Basil Bell, Zanzibar, Tanzania.

ATOMIC BOMB TESTS IN THE TUAMOTUS: A "before and after" program of scientific observations on the test area does not seem to have been formulated, or at any rate made known to the scientific community, when atomic testing was planned for the Tuamotus. That geological as well as biological surveys have been conducted is slowly becoming apparent as papers begin to appear (cf. Cahiers du Pacifique, below). An example is a report on borings on Mururoa Atoll, two of which reached the basaltic substratum (Chauveau, J.C., et al., C.R. Acad. Sci. Paris 265 (sér. D): 1113-1116, 1967). Dating of Mururoa limestones had been reported by Lalou, C., et al., loc. cit. 263 (sér. D): 1946-1949, 1966.

E. H. BRYAN HONORED: Ed Bryan has probably visited more atolls than anyone else and is certainly a walking encyclopedia of information on them. It seems fitting, therefore, to reproduce the following from Ka 'Elele, Staff Newsletter of the Bishop Museum, No. 53, 1968, for the benefit of our readers:

"On the occasion of his 70th birthday, April 13, Mr. Edwin H. Bryan, Jr., was appointed by the Trustees to be the first William T. Brigham Senior Fellow in recognition of nearly 50 years of distinguished service to Bishop Museum. The day began with a special honorary symposium and closed with a birthday dinner and the presentation of the award. The symposium, held in the Paki Hall Conference Room, included speakers from the University of Hawaii and the Museum staff, with Dr. Roland W. Force, Director of Bishop Museum, as Chairman. Entitled 'Aspects of Natural History in the Pacific', the five speakers and the papers given were: Dr. E. Alison Kay (University Professor and Chairman of General Science, and Museum Honorary Associate in Malacology), 'The History of Natural History in Hawaii'; Dr. Andrew J. Berger (University Professor and Chairman of Zoology, and Museum Honorary Associate in Ornithology), 'The Breeding Season of Hawaii 'Amakihi (Loxops virens)'; Dr. Harold T. Stearns (Consulting Geologist), 'Glaciation and Atolls'; Dr. John E. Randall (Hawaii Institute of Marine Biology, and Museum Ichthyologist), 'Fish Names of Tahiti'; and George W. Bunton (Kilolani Planetarium Astronomer), 'The Planetarium as a Classroom'. These and additional papers will be compiled in a special volume honoring Mr. Bryan and published by Bishop Museum Press at a future date. About 35 people, including Mrs. Bryan, took part. In the evening, some 100 friends and colleagues gathered at the Pacific Club for dinner and the award presentation. Mr. Bryan responded with a lively account of his reminiscences of the early days of the University and Bishop Museum.

"Philadelphia-born Ed Bryan, the man who knows the Pacific like the back of his hand, came to Hawaii in 1916, just out of a California high school. He attended the College of Hawaii, now the University, and graduated with a B.S. in 1920. A year at Yale earned him a Ph.B., and in 1924 he received his M.S. from the University of Hawaii. His interests in Pacific and Hawaiian Islands natural history were kindled

early in college by various science courses and associations with faculty scientists, and eventually he landed at Bishop Museum in 1919 as Assistant in Entomology, a part-time summer job that continued through his senior year. Thus began Ed Bryan's long career, as Curator of Collections for 32 years, contributor to scientific journals and the daily press for 46 years, traveler, astronomer, botanist, entomologist, geographer, historian, teacher, and bibliographer. For the past 8 years, as Manager of the Pacific Scientific Information Center, his continuing focus has been on efforts to make available to scientists everywhere the rapidly accumulating masses of data about the Pacific. He has served under four of the five Museum Directors and was acquainted with the first, Dr. William T. Brigham, for whom his new staff designation was named. His star charts, appearing in the Sunday paper, have been guides to Hawaii's skies since the early 1920's, and his "Bryan's Sectional Maps of Honolulu, Rural Oahu, and the Hawaiian Islands" is standard glove-compartment equipment for all motorists. Typically, he has moved into the next 70 years with characteristic vigor and enthusiasm for the countless projects and jobs that demand his attention in a growing Museum and a busy Information Center.

"Members of the committee who assisted Dr. Force in coordinating the events of the day were: Eleanor Anderson, Administrative Assistant to the Director; Brenda Bishop, Pacific Science Association; Dr. Dennis Devaney, Marine Biologist; Dr. Adrienne Kaeppler, Anthropologist; Dr. Kay; Dr. Yoshio Kondo, Malacologist; Dr. Randall; and Douglas Yen, Ethnobotanist."

EMORY FESTSCHRIFT: Another 70th birthday of an old atoll hand was that of Kenneth P. Emory. The Bishop Museum honored this event by publishing a book, Polynesian cultural history: Essays in honor of Kenneth P. Emory. We have not seen this yet, so cannot review it. Kenneth is the dean of Polynesian ethnology and archeology, and has been anthropologist on the Museum staff for over four decades and was recently appointed to the John Ledyard Chair in Cultural History. His investigations on Napuka and Kapingamarangi atolls, as well as others, are outstanding. We all wish him many more decades in which to get all he knows written down and published.

PROFESSOR RICHARD J. RUSSELL has recently published a book that will be of interest to the geologically and geographically minded among our readers, River plains and sea coasts, (Univ. Calif. Press). We hope to have a review of it soon.

MARINE SCIENCE INSTITUTE: We are distressed to read that the Marine Science Institute of the University of Miami has lost its library and many unpublished papers in a fire. There seems to be something seriously wrong with the economics and/or administration of science that such foreseeable catastrophes are allowed to happen in an age when fireproof construction is not only feasible but regarded as normal.

Dr. Donald P. deSylva, of the Institute, writes that he lost his entire personal library, as well as manuscripts and specimens, in the fire. He solicits reprints and other printed material to start rebuilding his library in the fields of ichthyology, fisheries, and biological

337-682 O-69—12

oceanography. We would suggest such contributions, also, to the library of the Institute of Marine Sciences, itself (Rickenbacker Causeway, Miami, Florida 33149, U.S.A.).

SYMPOSIUM ON CORALS AND CORAL REEFS: "The Marine Biological Association of India has great pleasure in proposing to hold a Symposium on CORALS AND CORAL REEFS as its fourth of the series of symposia during 12-16 January, 1969 at Mandapam Camp, India.

"The scientific study of coral reefs dates back to the time of Darwin. Since then, corals and coral reefs have attracted the attention of naturalists, marine biologists, geologists, palaeontologists and geographers alike, the world over. Corals comprise members of the Hydrozoa and of the Anthozoa. Perhaps there is no sphere of biological study in which the continual interplay between the animal and environment is so well displayed or worthwhile studying as in this group with its characteristic distribution. A coral reef harbours a rich and varied reef-building and reef-dwelling fauna and flora forming a unique biotype. The degree of variability within this group and the influence of several factors, especially the water movements, on their growth is remarkable. The building of the reefs is primarily a constructive biological process while the geological processes such as erosion and sedimentation which are continuously in action form the main destructive causes, the effects of which need study by scientists other than the biologists. Thus the study of coral reefs is intimately connected to the earth sciences. Information on the coral reefs for safe navigation is also quite obvious. Many an industry is dependent on corals for raw material. They are also much sought after as curios and for their ornamental and medicinal value.

"The late nineteenth and early twentieth century researches on this group have yielded many interesting results. Still, many major problems on the various aspects of this group remain to be satisfactorily explained. To review the past findings, to bring forth the results of current investigations and to discuss problems of interest for research in the light of the experience gained, it is felt desirable to hold a Symposium on the various aspects of coral and coral reefs, particularly their systematics, ecology and biology.

"Mandapam Camp has been chosen as the venue for this Symposium considering the unique opportunities this place lends for discussion on this particular subject. Perhaps this is one of the few places in the Indian region where a rich and active coral reef can be seen within a few metres from the shore and in the vicinity of a Research Institute. Mandapam itself is located on a narrow peninsula with seas on all the three sides. The shallow seas all around with a chain of coral islands on one side present a fascinating panorama to any visitor. It is no wonder that in view of the rich and varied marine fauna and flora in this area it is rightly known as the marine biologists' paradise.

"Contributions from scientists all over the world are invited on the following subjects:

"Systematics, Distribution, Physiology, Histology and Histo-Chemistry, Biology, Reproduction, Larval and Post-larval development, Phylogeny and Evolution, Formation of Coral reefs, Structure and Ecology of Coral reefs, Animal and Plant communities on reefs, Utility of Corals and Coral reefs and Review.

"Background papers on the above subjects are also invited.

"Titles of contributions for the symposium will be registered up to 31st July 1968. Abstracts of papers in triplicate should reach the Convener by 31st August 1968 and the full papers by 31st October 1968.

"All correspondence may be addressed to: The Convener, Symposium on Corals and Coral Reefs, Marine Biological Association of India, Marine Fisheries P.O., Mandapam Camp, Madras State, India."

Information furnished by the Convener.

SYMPOSIUM ON LIMESTONE-BORING ORGANISMS: Of much interest to our readers may be the following (quoted from AIBS Newsletter 1(12): 4, 1967): "An international symposium entitled Penetration of Calcareous Substrates by Invertebrates and Lower Plants is scheduled during the AAAS meetings at Dallas, Texas in December 1968. The symposium will be limited to papers on invertebrates and lower plants which mechanically, chemically or mechanically-chemically penetrate invertebrate and algal exoskeletons of calcite and aragonite, limestones, and composites containing a calcareous cementing mixture. Interested investigators are invited to submit, as soon as possible, a tentative title and brief summary of a proposed paper for consideration, and to indicate whether travel support will be required. Address all correspondence to: M. R. Carriker, Systematics-Ecology Program, Marine Biological Laboratory, Woods Hole, Massachusetts 02543."

SOUTH PACIFIC STUDY TOUR: The Department of Oceanography, University of Washington, has just announced a 3-week study tour to the South Pacific, to be sponsored by the University's Division of Evening and Extension Classes, and to be conducted by the Faculty of the Department of Oceanography. Among the features to be studied are the great Barrier Reef and Coral Atolls. The tour will take place January 11-February 1, 1969. Inquiries may be addressed to:

University of Washington
Division of Evening and Extension Classes
Seattle, Washington 98105

Original Observations

A NEW METHOD FOR SEWAGE TREATMENT ON CORAL ATOLLS

by Keith Marshall
c/o Dept. of Anthropology, University of Washington
Seattle Washington 98105, U.S.A.

Sanitary disposal of human and animal excreta is an important problem confronting people the world over which is accentuated for those people living on coral atolls. As island populations increase rapidly the problem of sewage treatment increases apace. A recent development in Taiwan promises to help alleviate sewage treatment problems and appears to be ideally suited for use on small coral islands: it is safe, simple, effective, and inexpensive.

In one form this invention is constructed of two metal drums, tubing, and a sealing lid all of which are placed in the ground under a privvy. Where corrosion of metal is a problem (as on atolls) the drums can be treated with a sealer. Only one drum is used at a time. When it is partially filled the head is sealed and a process of fermentation by anaerobic bacteria begins. This fermentation produces methane gas which can be used with a gas burner for cooking or with a gas mantle for lighting. Once fermentation in one drum is finished the residue is a sterile and usable fertilizer. By rotating the two drums one continuously is assured sanitation, light, heat, and fertilizer. Such a system appears to have great potential for use on coral atolls where pollution of the fresh water lens or the lagoon is an ever-present possibility.

One form of the invention which has been developed treats hog manure or chicken droppings rather than human waste.[1/] This unit has proved very successful on Taiwan and costs about U.S. $90.00 to construct. It is built using bricks or concrete blocks which are plastered and waterproofed on both sides eliminating the threat of seepage. A hole is dug and lined with sealed and plastered building blocks. This is then capped with a gasholder made of 16-gauge (1.5 mm) sheet iron. From the gasholder a hose can be run to carry the methane gas to its point of use.

Workers at the Animal Industry Division, Chinese-American Joint Commission on Rural Reconstruction, Taiwan, have ingeniously wedded the second method of methane production described above to Chlorella

---

1/ Plans for this system may be obtained by writing: China Productivity and Trade Center, 62 Sining South Rd., Taipei, Taiwan.

production.[2/] Produced in large quantities, this alga provides an animal feed of high nutritive value. Such a system has obvious implications for those islands lacking large quantities of suitable animal feed.

The above described sewage treatment systems merit further study not only by specialists in sanitary engineering and in public administration, but also by those in marine biology, in island ecology, and in anthropology.

A NOTE ON MEDITERRANEAN BEACHROCK: ITS HISTORY

by Andrew Goudie
Department of Geography, University of Cambridge

The existence of beachrock is now well established in the Mediterranean. Taillefer (1964) gave an interesting description of some beachrock at Viransehir, near Mersin, southern Turkey. During field work in 1965 at Arsuz, on the other side of the Gulf of Iskenderun from Mersin, I examined another large expanse of beachrock. Mistardis (1963, 1964) has made a thorough study of Greek examples, most of which are concentrated in Attica, and Boekschoten (1962, 1963) has described various Cretan beachrocks. There are also reports of beachrock from elsewhere in the Levant by Schattner (1967), Emery and Neev (1960) and Fevret and Sanlaville (1965). However, beachrock is not confined to the Eastern Mediterranean for Mabesoone (1963) and Russell (1962) mention examples from Cadiz and Barcelona in Spain, and Bloch and Trichet (1966) give details of a small exposure in Liguria, Northern Italy.

One problem which has concerned most of those who have investigated beachrock in the Mediterranean is the age of the deposits, and whether this age indicates some association with a slightly warmer phase in the past, for the northern Mediterranean is probably a fringe area for beachrock formation, and many examples are undergoing severe solutional alteration at present.

Taillefer (1964) believed that the beachrock at Viransehir was formed during the Monastirian and is now a relic feature suffering degradation. He based his evidence on the absence of included archaeological remains, and as Viransehir is very near to the major classical site of Pompeiopolis he believed that this absence was significant. However, it is doubtful if this date applies to other Turkish beachrock. The beachrock at Arsuz, for example, contains pots, bricks, and the like which are of Roman or Byzantine origin. Similarly, Emery and Neev (1960) state that one of the exposures of beachrock in Israel comes

---

[2/] Po, Chung, "The Animal-Methane-Chlorella Cycle, Additional Uses of Manure for Fuel and Food Production", Chinese-American Joint Commission on Rural Reconstruction, Taipei, August, 1965.

from "post-Roman or even post-Crusader times, as revealed by the inclusion of brick, pottery, and marble fragments in beachrock at Caeserea and Acre". In Greece, the beachrock overlies some reddish breccias of Upper Pleistocene age and some superficial sandstones of early Holocene/End Pleistocene age. The majority of the Greek examples are at present sea level which suggests no great age, though some examples are known from slightly below sea level. However, Mistardis (1963) mentions that some beachrock has been used in tomb construction dated at 1800 B.C. suggesting that in this case it is at least 4000 years old. Boekschoten (1962) says that some of the Cretan beachrock at Limani Chersonisos contains man-made green glass and concludes that as glass only came into general use in Roman times on Crete, and as Chersonisos became a rather important town in these times, as witnessed by many ruins not far from the beach, a terminus post quem of around 2000 years can be accepted for the beachrock formation. He writes, "Apparently nowadays the beachrock is eroded only; no phenomena could be observed which could be interpreted as accretion."

In this connection it is interesting that both Boekschoten (1962) and Bloch and Trichet (1966) state that the beachrock that they describe is bonded by a calcitic rather than aragonitic cement. Stoddart and Cann (1965) on the other hand suggest that true beachrock is initially cemented by aragonite. It is possible, therefore, that this calcitic bonding is a result of a formation in the past followed by subsequent alteration, for as Chilingar et al. (1967) write: "Diagenesis of modern carbonates is rapid if they are exposed to fresh water. Thus beachrock cements that are several thousand years old are converted to calcite."

Even the earliest investigators of beachrock were concerned with its age, and most of the earliest references to beachrock come from the Mediterranean's shores and from the Canary Islands. Darwin (1841) was not the first person to describe beachrock as was assumed by Russell and McIntire (1965). Joseph Woods (1824), for instance, wrote that in Attica "A conglomerate still more recent appears to be at present in the progress of formation in some places on the shore." Other early references to beachrock include Von Buch's (1825) description of the still-continued formation of conglomerates on the seashore near Las Palmas, and other mentions of similar deposits on the Sicilian coast near Messina by de Saussure, Spallanzani and others as mentioned by Bischof (1854).

However, the best early account of beachrock is that of Sir Francis Beaufort, the Admiralty hydrographer. His account of the "petrified beaches" of Karamania was published in 1817, and was based on laborious surveys during the Napoleonic War. He wrote (p. 174): "The shore bounding the plain was once a gravel beach; but from the upper part of the slope to some distance into the sea, it is now a solid crust of pudding stone, from one to two feet in thickness. The petrified beach is not peculiar to the Plain of Selinty: many instances of it on a smaller scale had been already observed on the coasts of Asia Minor, and a few in some parts of Greece; and I have been informed that an example of it also occurs in Sicily. Being generally covered with loose sand and pebbles, it presents to the eye no extraordinary appearance; but the unwary boat that should mistake it for a common beach of

yielding materials and should run upon it before a following surf, might be fatally apprized of its error."

Beaufort also describes the nature of the Turkish specimens and remarks that they "Differ but little from each other; gravel predominates in some, coarse sand in others; or they lie in alternate layers of each; the pebbles in all are more or less rounded....the cement or paste by which they are united are likewise calcareous, and so tenacious that a blow sufficient to break the mass, more frequently fractures even the quartz pebbles than dislodges them from their bed." He goes on to give an indication of their mode of formation in association with streams flowing from a small range of calcareous hills: "Perhaps the calcareous particles thus washed down may point out the source from whence the cement for this recently formed rock has been derived; and perhaps, wherever this petrified beach occurs, a similar mode of accounting for it might be furnished by an alternative investigation of the adjacent strata." This view is little different from that of Boekschoten (1962) who says that Cretan beachrock is linked in its occurrence with the two coastal outcrops of limnic neogene sediments, and that, "The ground-water, saturated with Calcium Carbonate from the freshwater limestone seeps out of the sands along the edge of the beach and causes cementation there...."

Of no less importance is Beaufort's assessment of the date of the beachrock from archaeological evidence. This is of particular interest because the beaches he deals with, like those of Taillefer (1964) mentioned earlier in this note, are very close to the ancient city of Pompeiopolis. His observations tie in well with those at Arsuz. He talks of a Roman port installation and says: "Several of the square blocks of stone which had fallen down from the piers, were buried in the crust; and though firmly fixed there, their original positions were still obvious, and had a freshness of appearance that proved how recent and rapid had been the petrifying process." At another point along the coast, "This rock contains a large proportion of broken tiles both red and yellow, of shells, bits of wood, and of such rubbish as might be expected in the vicinity of a town. It is uncommonly hard." These observations conflict with those of Taillefer (1964).

Thus Sir Francis Beaufort gave a remarkably penetrating account of these interesting littoral conglomerates. His work was referred to by Bischof (1854) and others, but otherwise has been rather neglected by coastal geomorphologists in comparison with later investigators like Darwin. He put forward useful ideas as to the age and origin of the beachrock, and gave some indication of its extent in the northern Mediterranean - an extent which only now is being fully realized. Beachrock is far from being a purely tropical phenomenon.

References

Beaufort, F. (1817). Karamania. London.

Bischof, G. (1854). Chemical and Physical Geology. London.

Bloch and Trichet (1966). Un Example de Grès de Plage. Marine Geology 4(5).

Boekschoten, G. J. (1962). Beachrock at Limani Chersonisos, Crete. Geologie en Mijnbouw 41(1): 3-7.

Boekschoten, G. J., (1963). Some Geological Observations on the Coasts of Crete. Geologie en Mijnbouw 42: 241-247.

Chilingar, G. V., Bissell, H. J. and Fairbridge, R. W. (1967). Carbonate Rocks. Developments in Sedimentology 9A, Amsterdam.

Darwin, C. (1841). On a Remarkable Bar of Sandstone off Pernambuco on the Coast of Brazil. London, Edinburgh and Dublin Philosophical Magazine and Journal of Science, Series 3, 19: 257-260.

Emery, K. O. and Neev, D. (1960). Mediterranean Beaches of Israel. Bulletin Geological Survey Israel, 26: 1-13.

Fevret, M. and Sanlanville, P. (1965). Contribution à l'Etude du Littoral Libanais. Méditerranée, p. 113.

Mabesoone, J. M. (1963). Coastal Sediments and Coastal Development near Cadiz (Spain). Geologie en Mijnbouw, 42(2): 29-43.

Mistardis, G. (1963). On the Beachrock of South East Greece. Deltion Ellenikes Geologie Etairias, Athens.

Mistardis, G. (1964). Shoreline Displacements and Sea Level Changes during the Middle-Upper Quaternary. 20th International Geographical Congress, Abstract of Papers Supplement, p. 21-22.

Russell, R. J. (1962). Origin of beachrock. Zeitschrift für Geomorphologie, 6: 1-16.

Russell, R. J. and McIntire, W. (1965). Southern Hemisphere Beachrock. Geographical Review, 55: 17-45.

Schattner, I. (1967). Geomorphology of the North Coast of Israel. Geografiska Annaler, 49(A): 310-320.

Stoddart, D. R. and Cann, J. R. (1965). The Nature and Origin of Beachrock. Journal of Sedimentary Petrology, 35(1): 243-247.

Taillefer, F. (1964). Le Grès de Plage de Viransehir. Revue Géographique de l'Est, 4: 393-398.

von Buch. (1825). Physikal Beschreibung der Canarische Inseln. Berlin.

Woods, J. (1825). Notice on the Rocks of Attica. Trans. Geol. Soc. London, II, 1: 172.

Publications

Wodzicki, K., An ecological survey of rats and other vertebrates of the Tokelau Islands. 1-89, 1-6, 1-4, 1, 1-4, 1-9, 1, 1-6, 1-12, Wellington, 1968. This duplicated report contains a remarkable amount of information about a previously poorly known group of atolls. The work was principally centered on rats, and was eminently practical in its objectives. It differs from many earlier investigations on rat problems in that its approach is primarily ecological, based on the premise that effective control is much more probable if based on an understanding of the ecology and population dynamics of the rats. In addition to the work on rats, birds and reptiles were studied to some extent, land invertebrates were collected and are being identified, parasites on rats were collected and a collection of plants prepared. A list of plants and brief description of the vegetation forms appendix VIII. Unfortunately there are some unexplained discrepancies between plants mentioned

in the text and those listed. This paper is a welcome addition to ecological literature on atolls.

Laird, M., A coral island experiment. WHO Chron. 21(1):18-26, [1967?]. We recently received this interesting article (also published in Danish, in Naturens Verden, Sept. 1967, 274-281) from the author, now of the Department of Biology of Memorial University of Newfoundland, St. Johns, Newfoundland, Canada. The experiments described concerned proposed methods of control of *Aedes* mosquitoes by chemical and biological agents on Nukunono and Atafu atolls, Tokelau group. Fakaofo Atoll was left untouched as a control.

Doumenge, F., L'Homme dans le Pacifique Sud. Etude géographique. Publ. Société des Océanistes No. 19, i-xxviii, 1-633 + 1, Paris, 1966. After the great French scientific expeditions of the first half of the 19th century, with their extensive publications, rather little attention was paid by the French to the Pacific Ocean, or even to their own islands of French Polynesia and New Caledonia, until World War II. There has been a profound change in this respect in recent decades, and the present volume is an example of it. It is itself a study of change in the Pacific Islands populations under the impact of 20th Century accelerated economic evolution. The author's "Pacific Sud" includes the tropical archipelagoes of the Southern Hemisphere, from the Solomon Islands to Easter Island. A few atolls of the Northern Hemisphere are included, where the Gilbert, Phoenix and Line groups straddle the Equator. As is usually the case with works of vast coverage, there is great unevenness in the treatment of various areas and topics. The French island groups are discussed in much greater and surer detail than those under English-speaking administrations and topics such as fisheries, industrialization, and migration and evolution of populations under the pressure of economic change are best developed, reflecting the author's particular interests and expertise. In the introductory section on the physical background, by contrast, the treatment of the biota is weak, and perhaps would have been better omitted altogether. The number of spelling errors in botanical names is staggering and cannot be entirely attributed to the vicissitudes encountered by this volume at the time of proofreading. They must be eliminated in a later edition or in the English version which has been mentioned as a possibility.

Coral atolls, of course, are not very important economically and much of this volume naturally does not pertain to them. Atoll students, however, will find here much information of value, especially on the Tuamotus. There is an account of the French atomic testing grounds and one of the first, if not the first, discussions in print of the tremendous impact of this enterprise on the people of the Tuamotus as well as other populations in French Polynesia, with some sober considerations for the future. The volume includes many tables, drawings, maps and photos, an extensive bibliography arranged by chapters and sections, and several indices. It is a most important addition to the literature of the 20th Century South Pacific Islands and few Pacific specialists will want to be without it.

Cahiers du Pacifique, the handsome journal sponsored by the French "Fondation Singer-Polignac" continues its valuable contribution to Pacific science with bibliographies, reviews and news, in addition to scientific papers. Nos. 10 (May 1967) and 11 (December 1967, received in 1968) include articles (some based on Mururoa surveys) on atoll molluscs and other invertebrates, as well as reports on fish-poisoning or "Ciguatera."

Journal de la Société des Océanistes. Some articles on atolls appear also in the latest issues of this journal, 22 (December 1966) and 23 (December 1967, received in mid-1968). The Journal regularly includes reviews and a continuing bibliography of Oceania. The series of "Publications" of the Society (of which no. 19 is described above) includes (no. 14, 1967) a "Bibliographie de Tahiti et de la Polynésie française," by P. O'Reilly and E. Reitman, which we have not yet seen. Its price (400 Francs) will no doubt limit its distribution despite the habitual high quality of works prepared by Father O'Reilly or under his guidance.

Dr. I. Eibl-Eibesfeldt's book on the Maldive atolls (see ARB 112: 9-10, 1965) has now been translated into English from the German original edition and is available in the U.S. as "Land of a Thousand Atolls," World Publishing Library, 1966.

Nelson, J. B. The biology and conservation of Abbott's Booby on Christmas Island. IUCN Bull. 2: 59, 1968. A brief account of Christmas Island (Indian Ocean) with the dismal prospects for its future, since phosphate exploitation is being stepped up, and remarks on status and future prospects of the endemic Abbott's Booby and other endemic birds.

Lundsgaarde, H. P. Social changes in the southern Gilbert Islands: 1938-1964. 1-51 + 8, Eugene, Oregon, undated, (mimeographed). This is a very informative account of present-day Gilbert Island life, well written and interesting. It is the fifth in a series of reports emanating from a project of the University of Oregon on "A comparative study of cultural change and stability in displaced communities in the Pacific" (see ARB 108, p. 1).

Lieber, M. D. Porakiet: a Kapingamarangi colony on Ponape. 1-228, Eugene, Oregon, 1968. This is an extremely informative monograph of this transplanted community of Polynesian atoll dwellers. Some background of history and geography of Kapingamarangi Atoll is included, largely borrowed from other sources. Comparisons between the two environments and between the human communities are very instructive. Of especial interest is an account of attempts to colonize Oroluk Atoll by the Kapingans. It did not work out very well. This document is the sixth in the University of Oregon series (see Lundsgaarde, above).

South Pacific Commission, Technical Meetings on Coconut Production, Rangiroa....Report. 1-31 + appendices, Noumea, 1967. This is an account of the discussions and list of papers presented at a meeting sponsored by the South Pacific Commission in August 1967. The papers were agricultural, phytopathological, physiological, and economic. Their texts were not published. Numerous recommendations were passed.

Zaiger, D. and Zentmyer, G. A. A new lethal disease of breadfruit in the Pacific Islands. Plant Disease Reporter 50 (12): 5 unnumbered pp., 1966. This paper and a report of subsequent work, P.A.Q.R.S. Cir. 36: 1-4, 1968, describe and give some data on the distribution of the Pingelap Disease, a serious threat to the breadfruit groves of the entire tropical Pacific, and other areas, too, for that matter. No cause for the disease has been established, though it seems highly infectious. Several fungi are associated with diseased plants, but cross inoculation was not successful.

Zipser, E. J., and Taylor, R. C. A catalogue of meteorological data obtained during the Line Islands experiment, February-April 1967. NCAR-TN-35, 1-362, 1968. A massive presentation of raw data, with a description of the experiment, maps, photos, and a very thorough bibliography of scientific publications on the northern Line Islands. It would be indispensable to anyone working on the meteorology or climatology of the Central Pacific. This document is also referred to as Hawaii Institute of Geophysics, University of Hawaii, HIG-67-19, apparently just to confuse bibliographers and librarians.

Sauer, J. D. Plants and man on the Seychelles Coast. 1-132, University of Wisconsin Press, Madison, Milwaukee and London, 1967. $5.00. This is a fine little book that deals in a most interesting manner with the history of the coastal vegetation (i.e., strand vegetation) of a fascinating group of islands in the western Indian Ocean. He treats the effect of 200 years of human influence, advances a theory of local origin for the coconut varieties cultivated in the Seychelles and elsewhere in the Indian Ocean, and lists the plants that make up the vegetation. The book is, in many ways, a model for reconstructions of vegetation from meager historical documentation.

Klausewitz, W., Die physiographische Zonierung der Saumriffe von Sarso. Meteor Forschungserg. D, 2: 44-68, 1967. A detailed and well illustrated consideration of reef zonation in the Sarso Islands in the Red Sea. Geomorphology, changes in sea level, and the biota are all presented in some detail, with excellent diagrams. This paper brings closer the day when we will have enough careful studies of reef zonation and geomorphology to yield some valid generalizations from a comparative study.

Maes, V. O., The littoral marine mollusks of Cocos-Keeling Islands (Indian Ocean). Proc. Acad. Nat. Sci. Phila. 119: 93-217, 1967. This is a handsomely illustrated account of a collection of shells made in 1963. In addition to a systematic enumeration of the collection the authors present a short account of the zoogeography and description of the atoll.

Lewis, A. G., Copepod crustaceans parasitic on fishes of Eniwetok Atoll. Proc. U.S. Nat. Mus. 125: 1-77, 1968. A descriptive systematic account with host records.

Menzies, R. J. and Frankenberg, D. Handbook on the common marine isopod crustacea of Georgia. 1-93, Univ. Georgia Press. Athens, Ga., 1966. This attractive booklet may be of help in identifying some of the isopods of the Caribbean reefs. It is largely based on collections made on Sapelo Island, Georgia, which, of course, is too far north to have coral reefs.

Mason, L. (ed.). The Laura report. 1-XXII, 1-83 + 2, 1-44 + 20, 1-58 + 6, 1-44 + 1, 1-30, I-VI. Honolulu, 1967. This is a series of reports resulting from a field training project based in Majuro Atoll, planned and conducted by Leonard Mason. The work was done and written up by teams composed of a graduate student and a Marshallese trainee. The four main reports are strictly sociological, despite the word "ecological" in the title of one of them. Interesting and valuable information was collected and is well presented. The background of experience gained by the participants must be regarded as extremely good training. The last of the five reports is one by Professor Mason, himself, on his project of providing a map of the Laura section of Majuro Islet, and is accompanied by a copy of the excellent and detailed map produced.

King, W. B. Seabirds of the Tropical Pacific Ocean. 1-126, Washington, D.C., 1967. Another in the series of Preliminary Smithsonian Identification Manuals (see ARB 100, p. 8), and it is, indeed, a valuable work. The main body of the book is a species identification guide, with keys, descriptions, and statements on flight, food, habitat and distribution. This material is presented in a succinct and eminently usable manner. In addition there are directions for recording observations and preserving specimens, a valuable bibliography, range maps, illustrations of silhouettes, and faunistic lists for the principal island groups in the Tropical Pacific. A complete index of species is provided. Although the manual is said to be preliminary, many people would be proud to produce a book of this quality and usefulness as the final product of long years of work.

Numata, M. Island Ecosystems of the Pacific Basin. Micronesica 3: 1-54, 1967. This interesting symposium was held at the 11th Pacific Science Congress, in Tokyo, in 1966, and the papers are here published. The papers are quite varied, but all in some way deal with the ecology of islands. Several deal specifically with atolls.

Fairbridge, R. W. (ed.) The Encyclopedia of Oceanography. 1-1021 Reinhold, N. Y., 1966. This is a magnificent volume--seldom has so much valuable scientific information been included in one book. Oceanographers, geologists, geographers, geochemists, geophysicists, and geomorphologists will find a wealth of material of interest. Biologists will fare less well, but there are some ecological articles, most of them not outstanding. The geographical articles are particularly extensive and valuable. Our more strictly atoll- and reef-oriented readers will be disappointed, especially since in a book edited by Rhodes Fairbridge they will naturally expect important writing on these subjects. There is no article on atolls, none on coral reefs, nor on any of the kinds or features of reefs, nor on any of the groups of organisms found on or making up these structures. We heartily recommend the book,

but not for its contribution to atoll or reef ecology. Why this is omitted from the scope of oceanography is puzzling.

Pimentel, R. A. Invertebrate Identification Manual. 1-151, Reinhold Publ. Corp., N. Y., Amsterdam, London, 1967. One of the difficulties encountered in any study or even casual observation of coral reefs and other littoral communities, is getting a working knowledge of the common animals seen there. These are so numerous and so varied, and modern zoology courses are so badly oriented, that most people do not have any idea even of the orders to which these animals belong. This book is an attempt toward remedying this situation. It does not pretend to be exhaustive, or to enable the user to determine species, or even genera. But it will help to give him an idea of where any animal fits in the animal kingdom, a prerequisite to finding out anything further. It is a very fully and effectively illustrated synopsis of the invertebrates and should be on the shelves even of competent invertebrate zoologists, as well as of the rest of us who like to know what we are looking at.

Hoyt, M. Jewels from the ocean deep. 1-258, G. P. Putnam's Sons, New York, 1967. $5.95. This is not a scientific book, but a hobbyist's guide to collecting marine shells. It is not intended for conchologists or malacologists, but would be extremely useful for anyone else who happened to need to know something about mollusks and their shells. It is a first-class job of writing and makes amazingly few errors, either factual or typographic. The abundant photos are good and very useful, though the reproduction leaves something to be desired.

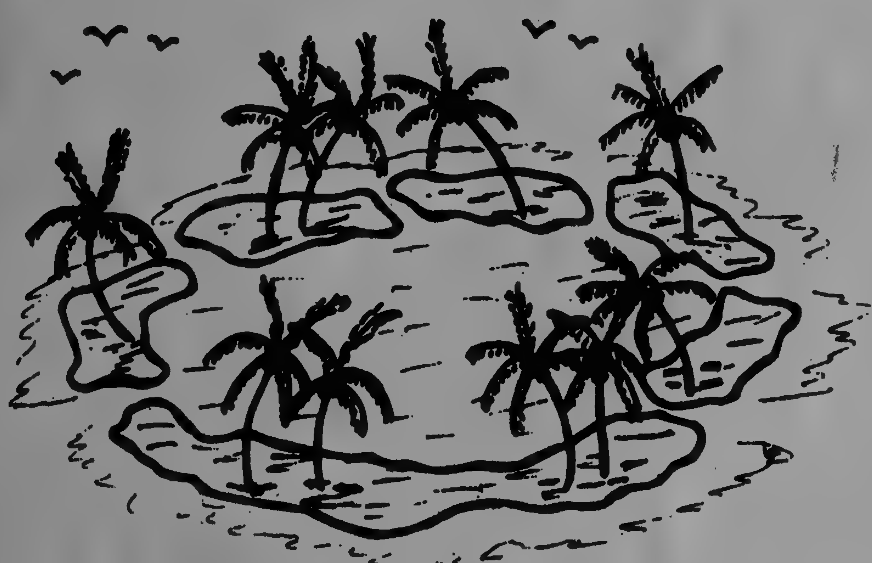
U.S. GOVERNMENT PRINTING OFFICE : 1969 O—337-682

May 28, 1969

ATOLL RESEARCH BULLETIN

No. 127 ***Ornithology of the Marshall and Gilbert Islands***

by A. Binion Amerson, Jr.



Issued by
THE SMITHSONIAN INSTITUTION
Washington, D.C., U.S.A.

ATOLL RESEARCH BULLETIN

No. 127

ORNITHOLOGY OF THE MARSHALL AND GILBERT ISLANDS

by A. Binion Amerson, Jr.

Issued by

THE SMITHSONIAN INSTITUTION

Washington, D.C., U. S. A.

May 28, 1969

ACKNOWLEDGEMENT

The Atoll Research Bulletin is issued by the Smithsonian Institution as a part of its Tropical Biology Program. It is supported cooperatively by the Oceanography, Ecology, and Systematics Programs and by the Smithsonian Press. The Press handles production and distribution. The editing is done by the Tropical Biology staff in the Museum of Natural History.

The Bulletin was founded and the first 117 numbers issued by the Pacific Science Board, National Academy of Sciences, with financial support from the Office of Naval Research. Its pages were largely devoted to reports resulting from the Pacific Science Board's Coral Atoll Program.

ORNITHOLOGY OF THE MARSHALL AND GILBERT ISLANDS[1]

by A. Binion Amerson, Jr.[2]

ABSTRACT

The avifauna of the Marshall and Gilbert Islands and the surrounding ocean consists of 79 species, of which 37 are seabirds and 42 are land and fresh-water birds. Of these 79 species, 20 are recorded here for the first time. One species, a procellarid, is recorded here as a new breeding record for the area. In addition, many species are new records for the 50 atolls and islands located within the area. Collected bird specimens from the Marshall-Gilbert area now total 1,133 (44 species), of which 585 (43 species) were collected by the Pacific Ocean Biological Survey Program. The average number of bird species per island is 13 in the Marshall-Gilbert area. A higher number of species exists in the extreme northern Marshalls than elsewhere in the area; the number decreases southward to the southern Marshalls; an increase occurs in the extreme southern Marshalls and further increases in the Gilberts. This north-south variation may be traced to a number of environmental factors.

1/ Paper Number 43, Pacific Ocean Biological Survey Program, Smithsonian Institution, Washington, D.C.

2/ Pacific Ocean Biological Survey Program, Smithsonian Institution, Washington, D.C.

CONTENTS

FIGURES

TABLES

Page

ATOLL MAPS

Acknowledgement is made to the United States Naval Hydrographic Office (H.O.) and to the United States Army Map Service (A.M.S.) for the atoll maps used in this paper. Island names are those used by the U.S. Board of Geographic Names.

Page

INTRODUCTION

In an area of some 600,000 square miles in the Western Pacific Ocean just west of the 180° meridian, lie the Marshall Islands and Gilbert Islands. Here some 50 atolls and reef islands are scattered north and south of the equator (Figure 1).

The Marshall Islands stretch from Taongi Atoll in the north (14°37'N) to Ebon Atoll in the south (04°37'N), and from Knox Atoll in the east (172°09'E) to Ujelang Atoll in the west (160°55'E). The Marshall Islands are divided into two groups, the eastern Radak Chain and the western Ralik Chain (Figure 2), and include 29 atolls and five reef islands.

Located just 200 miles southeast of the Marshall Islands are the Gilbert Islands which stretch from Little Makin Atoll in the north (30°17'N), across the equator to Arorae Island in the south (2°38'S) and east (176°49'E), and to Makin Atoll in the west (172°48'E). The Gilbert Islands comprise a single chain (Figure 3) and include 11 atolls and five reef islands.

Thus the Marshall and Gilbert Islands form an almost continuous chain of atolls running in a northwest-southeast direction. Various island groups surround the Marshall and Gilbert Islands: to the north lies Wake Island; to the northeast lie the Hawaiian Islands and Johnston Atoll; to the east and southeast lie Howland Island, Baker Island, the Phoenix Islands and the Tokelau Islands; to the south lie the Ellice Islands; to the west lie Ocean Island, Nauru Island, and the Caroline Islands; and to the northwest lie the Marianas Islands.

The Pacific Ocean Biological Survey Program (hereafter referred to as POBSP) of the Smithsonian Institution, Washington, D.C., is presently conducting an ecological survey in the Central Pacific Ocean, with particular emphasis on the avifauna. As part of this program, a two-month field trip to the Marshall and Gilbert Islands was made in October-November of 1964. Later studies were undertaken in June 1966 and in April-May 1967. This paper presents a summary of all known bird records from the two island groups.

ACKNOWLEDGEMENTS

Acknowledgement is made to the U.S. Navy, the U.S. Coast Guard, and the U.S. Military Sea Transport Service, who provided ship transportation for the POBSP field teams.

Special acknowledgement for cooperation and assistance is extended

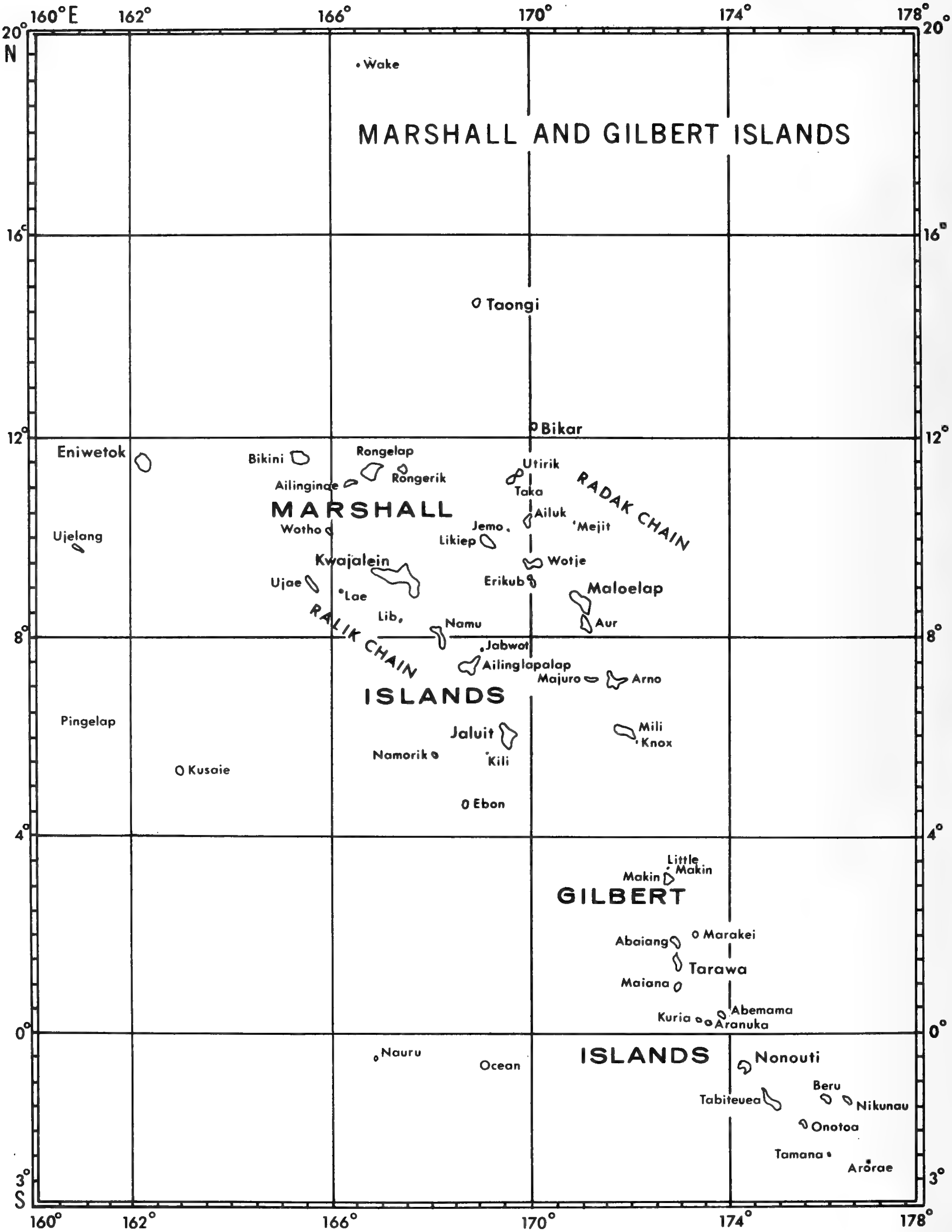


FIGURE 1. Marshall and Gilbert Islands Area Map.

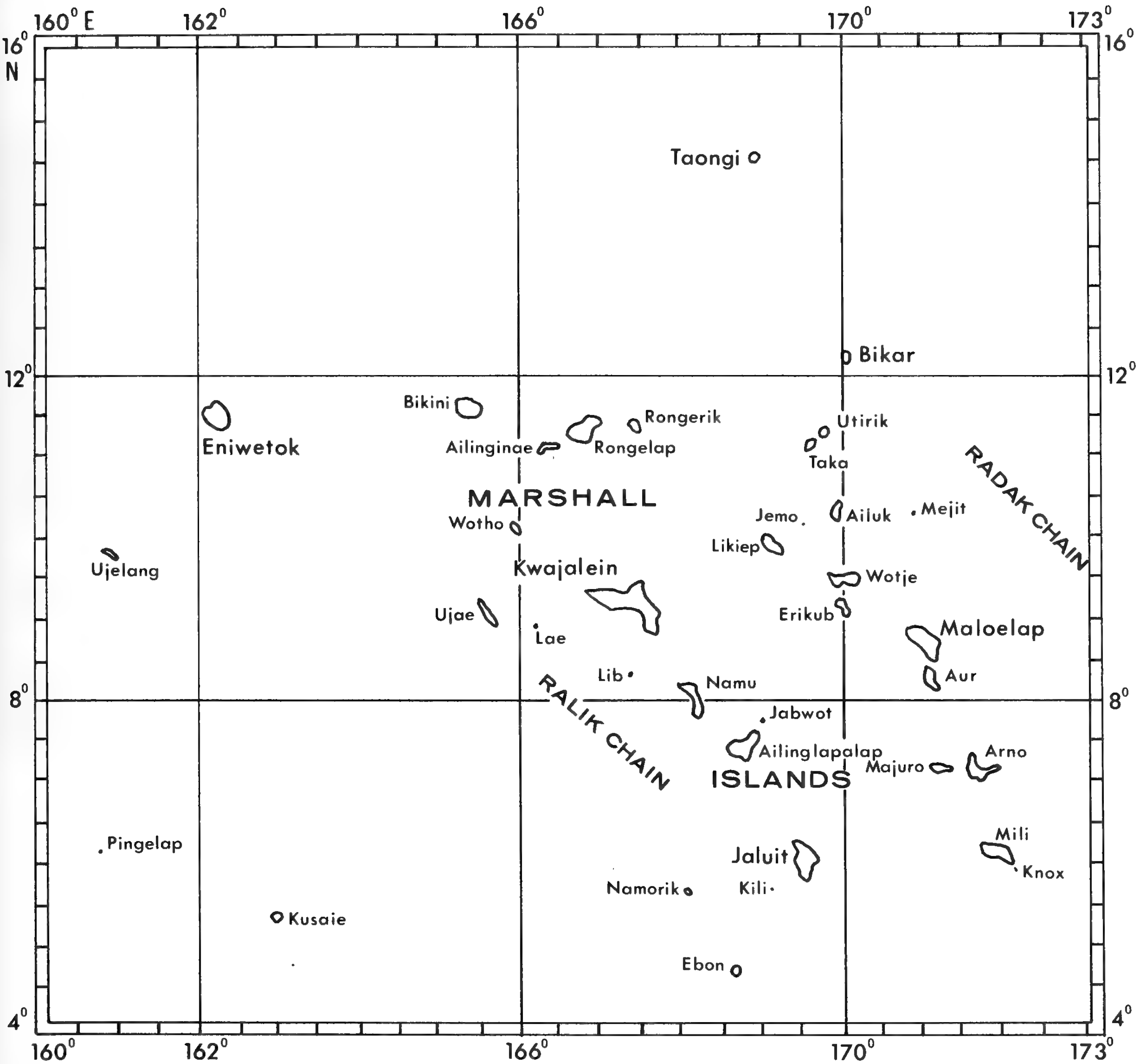


FIGURE 2. The Marshall Islands.

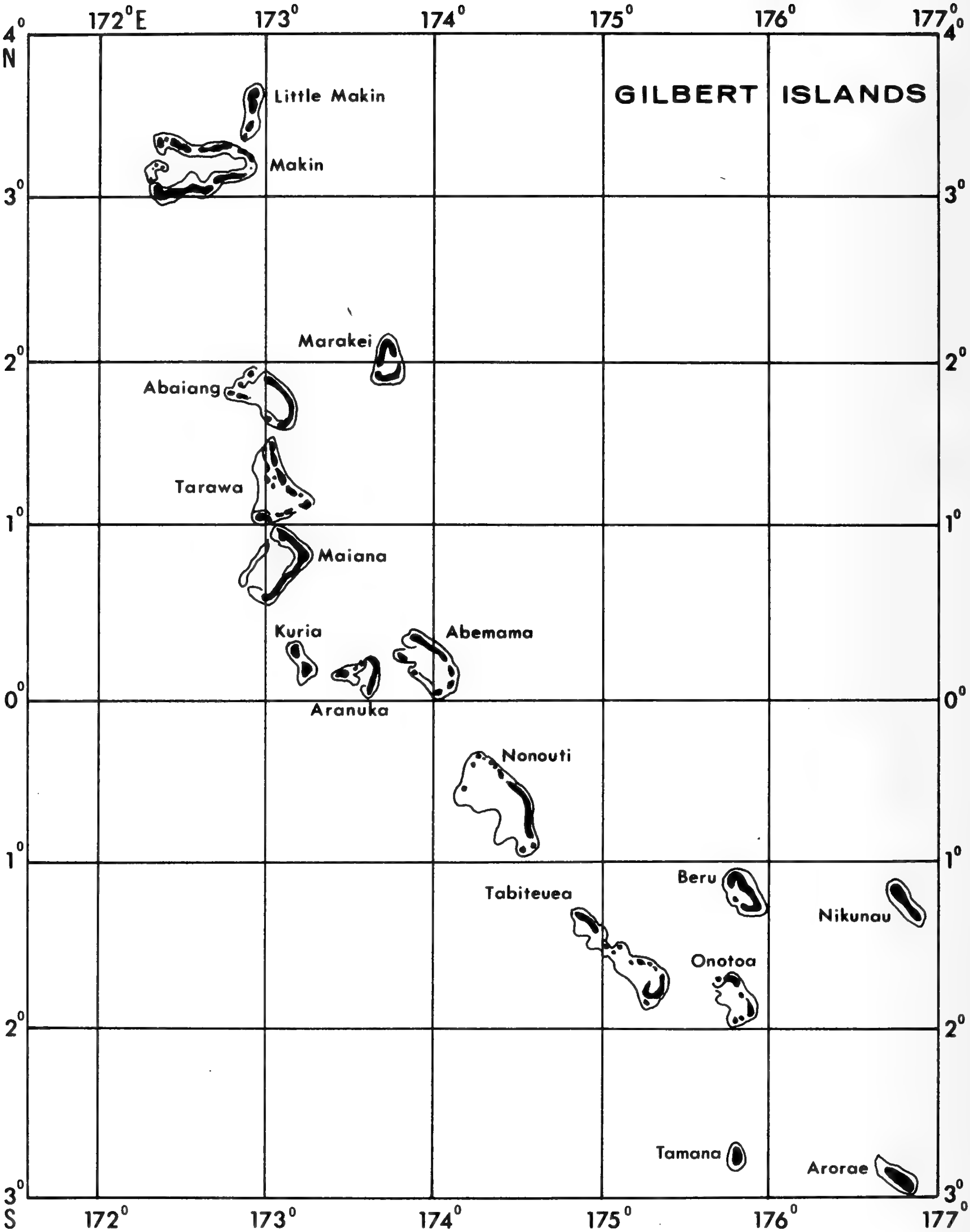


FIGURE 3. The Gilbert Islands.

to M.W. Goding, High Commissioner, Trust Territory of the Pacific Islands, U.S. Department of the Interior, and to the British Embassy, Washington, D.C., who, respectively, allowed the POBSP field team to visit the Marshall and Gilbert Islands. Special thanks are extended to R.J. McKay, representative, U.S. Trust Territory of the Pacific Islands, Kwajalein Atoll, for assistance on Kwajalein; to Colonel M.J. Small, Executive Officer, U.S. Army, Kwajalein Atoll, for assistance and transportation on Kwajalein; and to Major M.R. Thayer, Security Officer, U.S. Army, Kwajalein Atoll, for allowing field personnel to use firearms for collecting specimens on Kwajalein. Sincere thanks are extended to the many Marshallese and Gilbertese who assisted and guided the field teams on the various inhabited atolls. Acknowledgement is also extended to F.R. Fosberg, M-H. Sachet, and S.H. Riesenberg, Smithsonian Institution, Washington, D.C., for supplying information helpful in planning for the three trips. I wish also to thank George E. Watson whose critical comments concerning the manuscript were invaluable.

I am deeply indebted to many past and present personnel of the POBSP who contributed to this manuscript. Kenneth E. Amerman, Roger B. Clapp, Lawrence N. Huber, Dayle N. Husted, Philip N. Lehner, and George S. Wislocki devoted many long hours in gathering field data. Anne Keenan Poulson patiently drafted the many maps. Roger B. Clapp, Charles A. Ely, Patrick J. Gould, and Max C. Thompson provided assistance in identifying the unusual species collected by the field teams. Jan G. Reese and Robert A. Sundell cataloged most of the collected specimens into the USNM collection. I wish especially to thank Mae H. Esterline who edited the manuscript and who attended to all the details of producing the final copy. Helen H. Quinn typed the preliminary and final copies. Finally, I wish to thank Philip S. Humphrey whose patient guidance and insistent urging enabled me to complete this manuscript.

ORNITHOLOGICAL EXPLORATIONS

Historical Review

The first explorers to visit the Marshall and Gilbert Islands were people who probably came from Malaysia between 1000 and 1300 A.D. The first Europeans to visit these two island groups were Spaniards. Loyasa voyaged to the Marshall Islands in 1526 and Saavdera in 1529; Grijalva and Alvarado visited the Gilbert Islands in 1537. These early visitors made no significant bird observations. Chamisso (1821), as naturalist with the Russian expedition on the RURICK, under the command of Otto von Kotzebue, made detailed observations in the Marshall Islands in 1817 and 1818. Otto Finsch (1880a, 1880b) made ornithological observations in the Marshall and Gilbert Islands in 1879 and 1880. Wiglesworth (1893) summarized the ornithological work that had been done in the Gilbert Islands, adding only one species to the 19 recorded by Finsch.

Germany gained control of the Marshalls in 1885, and in 1899 Brondeis,

travelling on the German ship KAISERLAND, recorded birds from many of the atolls. The U.S. Fish Commission ship, ALBATROSS, visited the Marshall and Gilbert Islands in 1899 and 1900. Birds collected by this expedition were reported on by Townsend and Wetmore (1919). They listed six species from the Gilberts and five species from the Marshalls. The Gilbert Islands became a British protectorate in 1892 and a colony in 1915.

After World War I the Japanese gained control of Micronesia, which included the Marshall Islands but not the Gilbert Islands. Subsequently, Japanese ornithologists began investigating the avifauna of the area. Momiyama (1922) and the Ornithological Society of Japan (1932,1942) prepared lists of birds from Micronesia showing 29 species from the Marshalls.

United States forces occupied the Marshalls early in 1944, and after the Japanese surrender in 1945 the islands were under U.S. military control. In 1947 they became a United Nations Trust Territory under the administration of the United States. During World War II one ornithological report was made by servicemen stationed in the Marshall Islands (Gleize and Genelly, 1945), and the U.S. Navy Department (1943) published a handbook of the Marshall Islands which listed some of the animal life. The Laboratory of Mammalogy, U.S. Naval Medical Research Unit No. 2, collected animal specimens throughout Micronesia; none, however, were collected from the Marshall or Gilbert Islands (Baker, 1948). Birds were collected before and after the Bikini tests by J.P.E. Morrison (U.S. National Museum) and M.A. Traylor (Chicago Natural History Museum). Baker (1951) published the most comprehensive study to date on the avifauna of Micronesia. He included 39 species from the Marshall Islands, but none from the Gilberts.

In 1950, the SIM (Scientific Investigations in Micronesia) Project of the Pacific Science Board, National Research Council, conducted a survey of Arno Atoll, Marshall Islands. Subsequently, Marshall (1951) published an account of the vertebrate ecology of the atoll, listing 13 bird species. A similar study was conducted at Onotoa Atoll, Gilbert Islands. Moul (1954) reported on the land animals, listing 15 bird species. Various other reports have been published as a result of the U.S. Geological Survey and the Pacific Science Board's Micronesian investigation. Many have contained notes on birds (Fosberg, 1955, 1956; Wiens, 1957; Gressitt in Blumenstock, 1961). Fosberg (1966) published a detailed summary of his ornithological observations made in the Northern Marshalls (including Wake) during 1951, 1952, 1953, 1956, 1961, and 1963. He recorded 27 bird species from the 15 islands in the Northern Marshalls; he did not collect any specimens. Bryan (1965) listed 40 species of birds likely to be seen in the Marshalls; no distribution records were given.

Child (1960) published notes and observations on birds of the Gilbert Islands, listing 29 bird species. Morris (1963) listed 19 species of birds from the Gilberts, five of which had not been listed by Child. Bourne (1963) comments on Morris' paper and summarizes the literature from the Gilberts, but omits mention of Moul (1954) and Townsend and Wetmore (1919).

Pacific Ocean Biological Survey Program Explorations

The Marshall Islands and Gilbert Islands were visited by field personnel of the POBSP in October-November 1964, in June 1966, and again in April-May 1967, for the purpose of conducting a biological survey, with emphasis on the avifauna, on selected reef islands and atolls.

The POBSP personnel participating in the 1964 survey included: Kenneth E. Amerman, A. Binion Amerson, Jr. (biologist in charge), Roger B. Clapp, Lawrence N. Huber, Philip N. Lehner, and George S. Wislocki. This survey party left Honolulu, Oahu, Hawaii, aboard a U.S. naval vessel on 1 October and visited 11 atolls (Figure 4) as follows: Taongi (10-13 October), Bikar (14-19 October), Taka (19-23 October), Jemo (23-24 October), Erikub 24-28 October), Kwajalein(29 October - 9 November), and Jaluit (10-12 November) in the Marshall Islands; Makin 13-15 November), Maiana (16-17 November), Kuria (17-19 November), and Aranuka (19 November) in the Gilbert Islands. The ship arrived back in Honolulu on 27 November.

The 1966 survey was conducted by Dayle N. Husted, travelling aboard a U.S. Coast Guard vessel which departed Honolulu, Hawaii, on 2 June and visited Majuro Atoll (10-12 June), Kwajalein Atoll (13-14 June), and Eniwetok Atoll (21-22 June) in the Marshall Islands (Figure 4).

The 1967 survey was made by A. Binion Amerson, Jr., travelling aboard a U.S. naval vessel which departed Honolulu, Hawaii, on 17 April. Seven atolls were visited in the Marshall Islands (Figure 4) as follows: Taongi (29 April), Ailinginae (1 May), Jabwot (3 May), Erikub (4 May), Jemo (5 May), Taka (6 May), and Bikar (7 May). The ship returned to Hawaii 15 May.

Although since World War II there has been a sharp increase in the ornithological knowledge of the Marshall and Gilbert Islands, in many instances museum specimens are not available to substantiate sight records. Prior to the first POBSP survey in October-November 1964, 540 specimens of 21 bird species were known to exist. They are in the collection of the: U.S. National Museum, Washington, D.C. (USNM): Harvard Museum of Comparative Zoology, Cambridge (MCZ): University of Kansas Museum of Natural History, Lawrence (KMNH): University of Utah Zoology Museum, Salt Lake City (UUZM); University of Arizona Zoology Museum, Phoenix (UAZM); British Museum of Natural History, London (BMNH), and the Yamashina Institute of Zoology and Ornithology Museum, Tokyo (YIZM). Since 1964, 8 additional specimens have been collected and are in the collection of the Bowling Green (Ohio) State University Biology Museum.

In 1964 POBSP collected 445 specimens of 42 bird species. No specimens were collected by the POBSP in 1966. In 1967, 140 specimens of 21 species were collected by POBSP personnel, making a total POBSP collection of 585 specimens of 43 species. All the specimens are in the U.S. National Museum. Many of these are new records for the Marshall and Gilbert Islands.

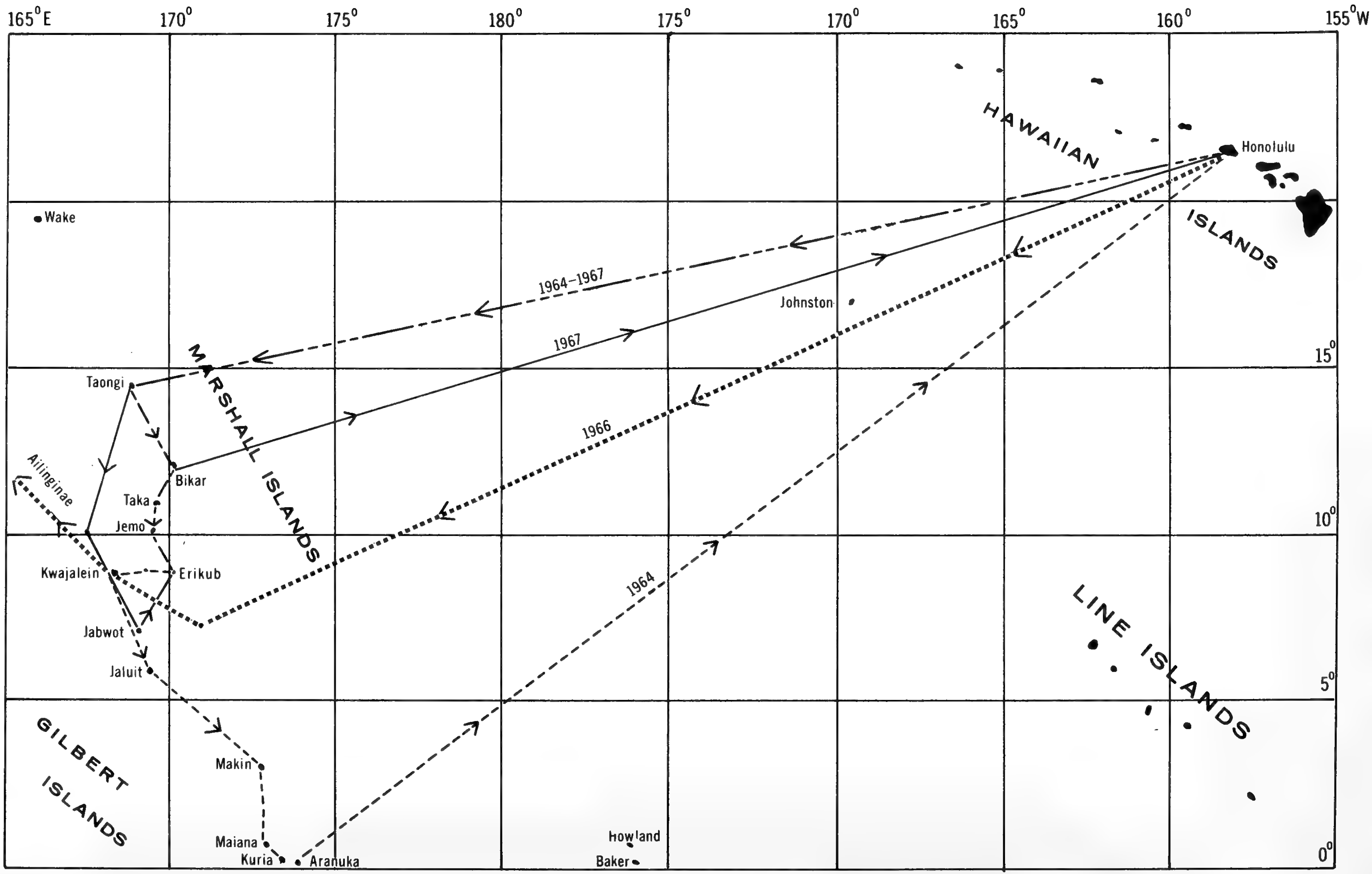


FIGURE 4 POBSP Itineraries: Marshall and Gilbert Islands– 1964, 1966, 1967.

ATOLL SUMMARIES

The following atoll summaries provide a brief description for each of the 50 atolls in the Marshall and Gilbert Islands. Each description includes a map, and gives location, shape and size, soil, vegetation, climate, and human population. The summaries also include a list of scientific visits.

The primary function of the atoll summaries is to provide background for an avifauna discussion for each of the 50 atolls. Each avifauna section includes a brief summary of the species recorded. An avifauna checklist for each atoll provides a listing of all known records, giving status and source of each record. Specimens collected by the POBSP and other collectors are listed for each atoll; museum numbers and collection data for each specimen are given. An annotated species account, listing habitat, numbers, status, and specimen records, is given only for atolls visited by the POBSP field teams during 1964 and 1967. To conserve space, all negative data have been omitted from the annotated species accounts.

All atolls are listed north to south for both the Marshall and Gilbert Islands, with those in the Marshalls divided into the Radak and Ralik chains. All island names used are official names adopted by the U.S. Board of Geographic Names.

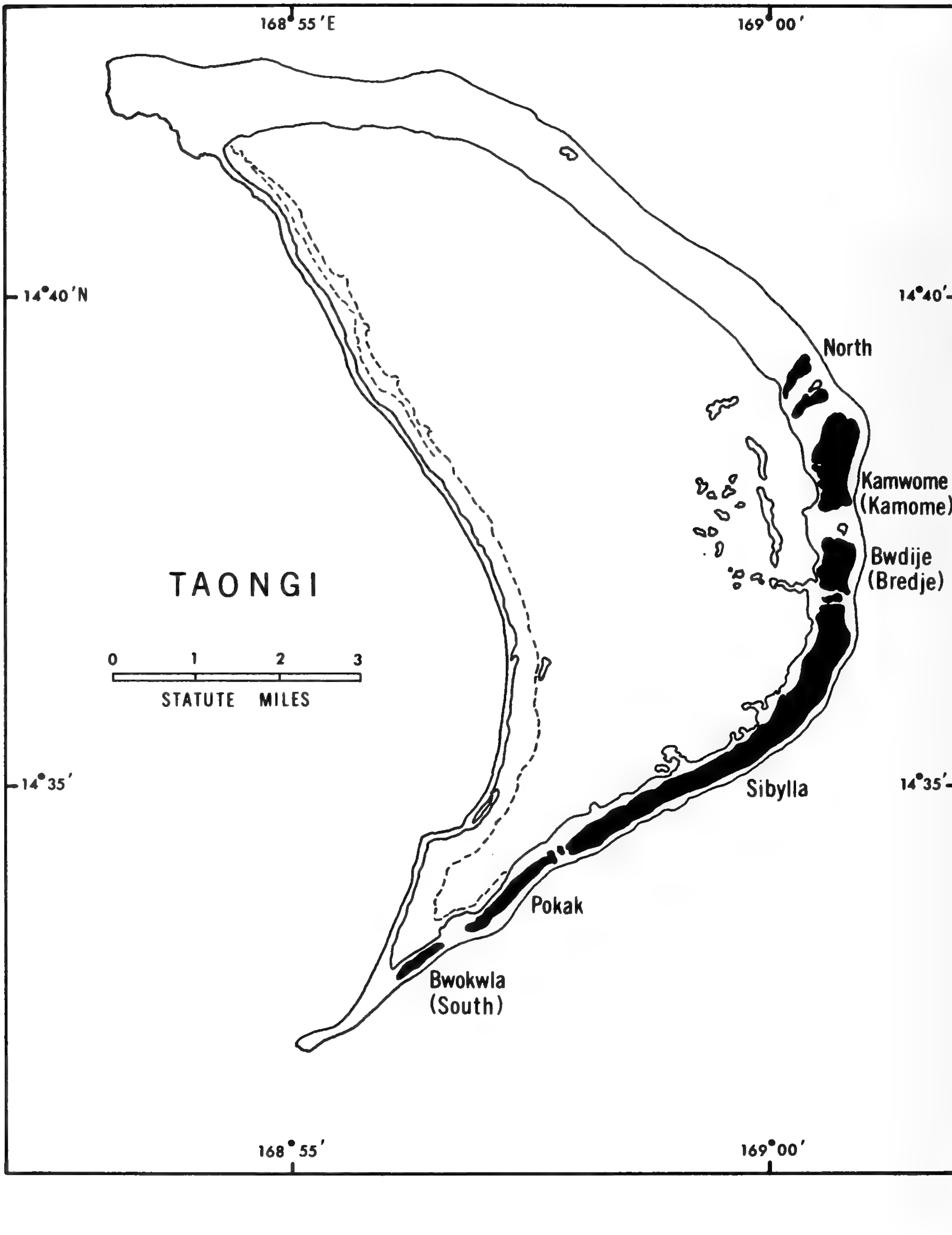
Several sources were used in assembling the common and scientific names of the birds occurring in the Marshall and Gilbert Islands. The names used in the American Ornithologists' Union's Checklist of North American Birds, 1957, 5th edition, were followed for species occurring in North America. In the interest of consistency, seabird names agree with those which appear in Watson's Smithsonian Identification Manual: Seabirds of the Tropical Atlantic Ocean, and King's Smithsonian Identification Manual: Seabirds of the Tropical Pacific Ocean. Alexander's Birds of the Ocean, Mayr's Birds of the Southwest Pacific, Baker's Avifauna of Micronesia, and the Ornithological Society of Japan's A Hand-list of Japanese Birds, 1958, 4th and revised edition, were used in several instances.

Taxonomic order follows that of Peter's Checklist of the Birds of the World, volumes I, II, and III, with the exception of the Procellariiformes, which follow Alexander, et al. (1965), the Anserformes, which follow Delacour (1954,1959), and the Charadriiformes, which follow Bock (1958).

For descriptions and illustrations of the 79 species of birds that are herein recorded, the reader is referred to the ornithological sources cited abcve.

M A R S H A L L   I S L A N D S

R A D A K   C H A I N


168° 55′E
169° 00′
14°40′N
14°40′
14°35′
14°35′
168° 55′
169° 00′
TAONGI
0 1 2 3
STATUTE MILES
North
Kamwome
(Kamome)
Bwdije
(Bredje)
Sibylla
Pokak
Bwokwla
(South)

TAONGI ATOLL

Location: 14°37' N x 168°58' E.

Shape and Size: Crescent shaped; Tip to tip - 11 miles; Convex (east or windward) side - 21 miles; Concave (west) side - 14 miles; Widest point - 5+ miles; Total lagoon area - 41.30 square miles; Total dry land area - 1.45 square miles; Number of islands - 13; Height - 12+ feet (Fosberg, 1956).

Soil: Beach (ocean side) - solid coral rock, cobblestone, huge boulders, some sandy area; Beach (lagoon side) - mostly sand, some stony and coral rock areas, scattered boulders.

Vegetation: Nine species; primary species - Messerschmidia, 10 - 15 feet high; secondary species - Scaevola, 3-6 feet high (Fosberg, 1956). Pokak, Sibylla, and Breje Islands - very thick vegetation, some sparse grassy areas;Kamome Island - sparse vegetation, large grassy areas.

Climate: Generally dry, about 40-50 inches of rainfall yearly; Mean air temperature-82° F; Wind - prevailing from east to northeast (Fosberg, 1956).

Human Population: Past - not inhabited, but occasionally visited by Marshallese who regarded it as a bird refuge and carefully regulated the harvesting of eggs and young birds (Fosberg, 1957); Present - not inhabited, but evidence remains of survivors of shipwrecks in 1964.

Scientific Visits: Northern Marshall Islands Expedition - 25 November 1951 (examined only from ship), 25 March 1952 (examined only from ship), 20-27 July 1952; POBSP - 10-13 October 1964, 29 April 1967.

Avifauna: Twenty-six bird species are presently known from Taongi Atoll. These include 19 seabirds, 5 shorebirds, 1 duck, and 1 heron. Twelve of these species are known breeders, six others are possible breeders, six are migrants, one is an at-sea visitor, and one is an accidental.

Taongi Atoll is the only known breeding ground in the Marshall and Gilbert Islands of Puffinus nativitatus. The same is probably true for Bulweria bulwerii. Although of accidental status, Puffinus assimilis is known in the Marshall and Gilbert Islands only from Taongi Atoll.

Twenty-six species are listed in the following checklist, which was derived from various sources: (1) POBSP, (a) 1964, (b) 1967 ; (2) Fosberg, (a) 1955, (b) 1966; (3) A.O.U. Checklist, 1957; (4) Peters, 1931; and (5) Mayr, 1945. These sources are referred to on the checklist by corresponding numbers and letters. The six species marked by a single asterisk are new species records for Taongi Atoll; the single species marked by double asterisks is a new atoll breeding record.

Taongi Atoll Avifauna Checklist

	Species	Status	Source
1)	Diomedea nigripes (offshore only)	Visitor (at sea)	2b, 3, 4, 5
2)	Bulweria bulwerii*	Resident breeder ?	lb
3)	Puffinus pacificus	Resident breeder	lab, 2b
4)	Puffinus nativitatus*	Resident breeder**	lab
5)	Puffinus assimilis*	Accidental	la
6)	Phaethon rubricauda	Resident breeder	lab, 2b
7)	Phaethon lepturus	Resident breeder ?	lb, 2b
8)	Sula dactylatra	Resident breeder	lab, 2ab
9)	Sula sula	Resident breeder	lab, 2b
10)	Sula leucogaster	Resident breeder ?	lab, 2b
11)	Fregata minor	Resident breeder	lab, 2b
12)	Egretta sacra	Resident breeder ?	lab, 2b
13)	Anas acuta*	Migrant	la
14)	Pluvialis dominica	Migrant	lab, 2b
15)	Numenius tahitiensis	Migrant	lab, 2b
16)	Heteroscelus incanum	Migrant	lab, 2b
17)	Arenaria interpres	Migrant	la, 2b
18)	Crocethia alba*	Migrant	la
19)	Sterna sumatrana*	Resident Breeder ?	la
20)	Sterna lunata	Resident Breeder ?	lb, 2b
21)	Sterna fuscata	Resident breeder	lab, 2b
22)	Thalasseus bergii	Resident breeder	lab, 2b
23)	Procelsterna cerulea	Resident breeder	lab, 2b
24)	Anous stolidus	Resident breeder	lab, 2b
25)	Anous tenuirostris	Resident breeder	lab, 2b
26)	Gygis alba	Resident breeder	lab, 2b

POBSP personnel have collected 53 specimens of 17 species (Table 1). Of these 17 species, 4 are specimen records of species not previously known from the atoll; the other 13 represent the first specimen confirmation of species previously known only from sight records. No other specimens are known from Taongi Atoll.

Species Account

1) Diomedea nigripes — Black-footed Albatross

Habitat -- November 1951 and March 1952 - observed offshore only (Fosberg, 1966).

Numbers -- November 1951, March 1952 - one seen offshore on both occasions. None seen on land during subsequent visits (Fosberg, 1966).

TABLE 1. Bird specimens collected by POBSP on Taongi Atoll

Species	Museum		Sex	Age	Location	Date	Status	Collector
Bulweria bulwerii	USNM	543452	♂	A	Lagoon	4-29-67	Skin	Amerson
Puffinus pacificus	"	543463	♂	A	Sibylla	"	"	"
" "	"	543058	♀	A	"	"	"	"
" "	"	543059	♀	A	"	"	"	"
" "	"	543464	♀	A	"	"	"	"
Puffinus nativitatus	"	494821	?	A	Kamome	10-12-64	"	"
" "	"	543461	♀	A	Sibylla	4-29-67	"	"
" "	"	543462	♂	A	"	"	"	"
Puffinus assimilis	"	494142	?	A	Breje	10-11-64	Skel.	"
Phaethon rubricauda	"	543055	♂	A	Sibylla	4-29-67	Skin	"
" "	"	543056	♂	A	"	"	"	"
Sula dactylatra	"	543057	♀	SA	"	"	"	"
Sula sula	"	543053	?	A	"	"	"	"
" "	"	543054	♀	A	"	"	"	"
" "	"	543348	♂	A	"	"	"	"
" "	"	543349	♂	I	"	"	"	"
Fregata minor	"	543385	♂	A	"	"	"	"
" "	"	543385	♂	A	"	"	"	"
" "	"	543376	♀	A	"	"	"	"
" "	"	543377	♀	A	"	"	"	"
" "	"	543378	♂	I	"	"	"	"
Egretta sacra	"	494853	♀	A	Kamome	10-12-64	"	-
Pluvialis dominica	"	494744	♀?	A?	Sibylla	"	"	Huber
" "	"	543386	♀	A	"	4-29-67	"	Amerson
Numenius tahitiensis	"	502901	?	A?	"	10-11-64	Alcoh.	-
Heteroscelus incanum	"	502902	?	A?	"	10-12-64	"	Amerson
" "	"	494890	♀	-	"	"	Skin	-
" "	"	494891	?	-	"	"	"	Clapp
" "	"	494892	♀	-	"	"	"	"
" "	"	494893	♂	-	"	"	"	"
" "	"	494894	♂	-	"	"	"	"
" "	"	494889	♂	-	"	"	"	Lehner
Sterna sumatrana	"	494584	♂	A	"	10-11-64	"	"
" "	"	494585	♂	A	"	"	"	"
" "	"	494586	♀	A	"	"	"	"
" "	"	494587	♂	A	"	"	"	Huber
Sterna fuscata	"	494691	-	-	Kamome	10-12-64	"	Amerson
" "	"	494692	♀	-	"	"	"	"
" "	"	494693	♀	-	"	"	"	"
" "	"	494694	♀	-	"	"	"	"

TABLE 1. Bird specimens collected by POBSP on Taongi Atoll

Species	Museum	Sex	Age	Location	Date	Status	Collector
Sterna fuscata	USNM 494695	♂	-	Kamome	10-12-64	Skin	Amerson
" "	" 393696	♀	-	"	"	"	"
" "	" 494697	♂	-	"	"	"	"
" "	" 494698	♀	-	"	"	"	"
" "	" 494699	♀	-	"	"	"	"
" "	" 494700	♀	-	"	"	"	"
" "	" 543389	♀	A	Sibylla	4-29-67	"	"
Thalasseus bergii	" 543429	♀	A	"	"	"	"
" "	" 543430	♂	A	"	"	"	"
" "	" 543431	♀	A	"	"	"	"
Anous stolidus	" 543410	♂	A	"	"	"	"
Gygis alba	" 543448	♀	A	"	"	"	"
" "	" 543218	?	-	"	"	"	"

Status -- At-sea visitor. No valid breeding record exists, although Mayr (1945) lists the Marshall Islands as a breeding ground, and A.O.U. checklist (1957) lists Taongi as a breeding locality. Neither gives source of information. Peters (1931) lists the Marshall Islands as part of the range of this species.

Specimen Records -- None.

2) Bulweria bulwerii Bulwer's Petrel

Habitat -- April 1967 - POBSP personnel observed Bulwer's Petrel at sea just off the east shore flying away from the atoll at dawn. None could be found on Sibylla Island during the day, although a thorough search was made over all portions visited. Many were observed late in the evening flying eastward over the lagoon toward the islands.

Numbers -- April 1967 - offshore 50±.

Status -- Resident breeder? April 1967 - probably breeding, one specimen collected over the lagoon was in breeding condition and had bare brood patches. If this species breeds on Taongi, it is a new breeding record for the Marshall Islands.

Specimen Records -- Other - none; POBSP - one (Table 1). This specimen represents a new specimen record for the Marshall Islands.

3) Puffinus pacificus Wedge-tailed Shearwater

Habitat -- July 1952 - saw this species "a short distance inland from the lagoon shore of Sibylla, Breje, Kamome, and North Islands." Burrows were placed in soft sandy soil on top of which bunch grass normally grew (Fosberg, 1966). POBSP personnel found this species on Kamome Island in 1964 and on Sibylla Island in 1967. Burrows were found on Sibylla in 1964 but were unoccupied.

Numbers -- July 1952 - tens of thousands (Fosberg, 1966); October 1964 - Kamome 2,000+, Sibylla ?; April 1967 - Sibylla 10,000; number banded 489.

Status -- Resident breeder. July 1952 - "eggs to nearly grown young in various stages of feathering out, up to those almost ready to fly." (Fosberg, 1966); October 1964 - large young, some feathering, present; April 1967 - pairing, courtship, burrows being dug, no eggs.

Specimen Records -- Other - none; POBSP - four (Table 1). This collection represents a new specimen record for Taongi Atoll.

4) Puffinus nativitatus Christmas Shearwater

Habitat -- October 1964 - Kamome, seaward beach area sitting among

low Scaevola bushes; April 1967 - in shallow burrows under large coral rocks located on the interior portion of Sibylla.

Numbers -- October 1964 - Kamome one seen; April 1967 - Sibylla 100's seen.

Status -- Resident breeder. October 1964 - no evidence of breeding; April 1967 - on eggs. This is the first breeding record for this species in the Marshall Islands.

Specimen Records -- Others - none; POBSP - three (Table 1). These specimens represent the first record of this species in the Marshall Islands. [Baker (1951) lists two specimens from Ailuk Atoll; however, this record is considered to be incorrect, see discussion under Ailuk Atoll].

5) Puffinus assimilis Little Shearwater

One found dead (mummy) on 11 October 1964 at Breje Island, high up on seaward sandy beach, apparently deposited there by extreme high tide.

Specimen Records -- Other - none; POBSP - one (Table 1). This specimen represents the only record of this species in Micronesia. It is considered to be an accidental.

6) Phaethon rubricauda Red-tailed Tropicbird

Habitat -- July 1952 - flying over all islets but nesting only on Sibylla, Breje, Kamome, and North; eggs laid on ground or sand in open brush (Fosberg, 1966); October 1964 - on all islands in the atoll, with nests usually under Scaevola or Messerschmidia bushes; April 1967 - on Sibylla, nests associated with above plant species.

Numbers -- July 1952 - fairly common (Fosberg, 1966); October 1964 - Sibylla 400, Kamome 25, Breje 100+; April 1967 - Sibylla 100±; number banded 36.

Status -- Resident breeder. July 1952 - eggs to almost grown young (Fosberg, 1966); October 1964 - eggs to very large young; courtship behavior also observed; April 1967 - eggs only, courtship behavior observed.

Specimen Records -- Other - none; POBSP - two (Table 1). This is a new specimen record for Taongi Atoll.

7) Phaethon lepturus White-tailed Tropicbird

Habitat -- July 1952 - observed flying over the seaward side of Sibylla (Fosberg, 1966); April 1967 - observed flying over Sibylla.

Numbers -- July 1952 - one observed flying (Fosberg, 1966); October 1964 - none observed; April 1967 - Sibylla two.

Status -- Resident breeder? July 1952 - no evidence of breeding; April 1967 - courtship behavior observed.

Specimen records -- None.

8) Sula dactylatra Blue-faced Booby

Habitat -- March 1952 - observed flying and fishing in small numbers offshore (Fosberg, 1966); July 1952 - "almost anywhere on the atoll except South Islet, always sitting on the ground or flying" (Fosberg, 1955); October 1964 - found around perimeter of Sibylla, Breje, and Kamome, nests placed on upper sand beaches, and scattered on the ground among Scaevola and Messerschmidia bushes; April 1967 - found around outer beaches of Sibylla.

Numbers -- July 1952 - no population estimate given; October 1964 - Sibylla 400, Kamome 50; April 1967 - Sibylla 2-300; number banded 106.

Status -- Resident breeder. July 1952 - young present (Fosberg, 1966); October 1964 - pairs forming, few with eggs, no young seen; April 1967 - eggs to large downy young present.

Specimen records -- Other - none; POBSP - one (Table 1). This specimen is the first of this species to be collected from Taongi Atoll.

9) Sula sula Red-footed Booby

Habitat -- March 1952 - fishing offshore, July 1952 - roosting in trees on all parts of the islet where Tournefortia or Pisonia trees occur (Fosberg, 1966); October 1964 - roosting and nesting primarily in Scaevola and Messerschmidia bushes on all islands; April 1967 - roosting and nesting on Sibylla as above.

Numbers -- July 1952 - large numbers (Fosberg, 1966); October 1964 - Sibylla 3,000, Breje 1,000, Kamome 500; April 1967 - Sibylla 2,000; number banded 335.

Status -- Resident breeder. July 1952 - one egg, very few young seen (Fosberg, 1966); October 1964 - 600± nests, many with fresh eggs, no young, some nest building; April 1967 - downy young present.

Specimen Records -- Other - none; POBSP - four (Table 1). These specimens represent a new record for Taongi Atoll.

10) <u>Sula leucogaster</u> Brown Booby

Habitat -- March 1952 - offshore, July 1952 - flying over seaward beaches and reefs during day, when sitting, usually on the ground or on rocks (Fosberg, 1966); October 1964 - roosting and resting on seaward (windward) side of Sibylla, nests placed on ground between scattered <u>Scaevola</u> and <u>Messerschmidia</u> bushes; April 1967 - adults and immatures flying about Sibylla.

Numbers -- March 1952 - large numbers offshore, July 1952 - many seen, but hard to estimate numbers (Fosberg, 1966); October 1964 - Sibylla 150; April 1967 - Sibylla 50; number banded 24.

Status -- Resident breeder? July 1952 - possibly prenuptial period (Fosberg, 1966); October 1964 - pairs forming, no nests observed; April 1967 - possibly breeding, did not visit all of Sibylla.

Specimen Records -- None.

11) <u>Fregata minor</u> Great Frigatebird

Habitat -- July 1952 - nests in <u>Tournefortia</u> trees, scattered over all islands except South Island (Fosberg, 1966); October 1964 - roosts and nests on all islands except South and Pokak, in <u>Messerschmidia</u> and <u>Scaevola</u>, 4-10 feet up; April 1967 - roosting and nesting in <u>Messerschmidia</u> and <u>Scaevola</u> on Sibylla.

Numbers -- November 1951 - as many as 25 at a time flying offshore, March 1952 - 8-10 followed ship; July 1952 - enormous population nesting (Fosberg, 1966); October 1964 - Sibylla 4,000-5,000, Breje 2,000, Kamome 300; April 1957 - Sibylla - 3,000; number banded 1.

Status -- Resident breeder. July 1952 - eggs and young in all stages of development (Fosberg, 1966); October 1964 - courtship observed, eggs to nearly flying young; April 1967 - courtship, eggs to large young.

Specimen Records -- Other - none; POBSP - five (Table 1). This represents a new specimen record for the atoll.

12) <u>Egretta sacra</u> Reef Heron

Habitat -- Common along entire exposed reef at low tide; found frequently along lagoon side of island.

Numbers -- July 1952 - 3 blue, 1 mottled, and 4 white seen (Fosberg, 1966); October 1964 - Sibylla 25-30, Kamome 4 (these were blue, white, and mottled); April 1967 - Sibylla 5.

Status -- Resident breeder? No evidence of breeding; however, there is a possibility that it breeds on the atoll.

Specimen Records -- Other - none; POBSP - one (Table 1). Although Fosberg observed this species in July 1952 at Taongi Atoll, this specimen represents the first museum specimen record from the atoll.

13) Anas acuta Pintail Duck

Habitat -- October 1964 - flying over Sibylla.

Number -- 11 October 1964 - Three very large, brown female or winter-plumage birds, probably Anas acuta.

Status -- Migrant.

Specimen Records -- None. This sight record is a new bird record for Taongi Atoll.

14) Pluvialis dominica Golden Plover

Habitat -- July 1952 - Observed "on any open space" (Fosberg, 1966); October 1964 - on all islands in the atoll, especially along the lagoon side; April 1967 - observed on the beaches of Sibylla.

Numbers -- July 1952 "seen now and then, one to three at a time" (Fosberg, 1966); October 1964 - Sibylla Island 200, Kamome Island 300; April 1967 - Sibylla 12; number banded 76.

Status -- Migrant.

Specimen Record -- Other - none; POBSP - two (Table 1). This constitutes a new specimen record for Taongi.

15) Numenius tahitiensis Bristle-thighed Curlew

Habitat -- July 1952 - "mostly on Sibylla, Breje, and Kamome Islets," seen on the beach and lagoon shore (Fosberg, 1966); October 1964 - Discovered on sandy and rocky seaward and lagoon beaches of all islands; April 1967 - observed on rocky portion at north end of Sibylla.

Numbers -- July 1952 - "were seen more commonly than on any of the atolls visited [in the northern Marshall Islands]," 2-15 seen at a time (Fosberg, 1966); October 1964 - common on all islands, Sibylla 50, Kamome 10; April 1967 - Sibylla 1; number banded 11.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - one (Table 1). This represents a new specimen record for Taongi Atoll.

16) <u>Heteroscelus incanum</u> Wandering Tattler

Habitat -- July 1952 - passages and reef flats (Fosberg, 1966); October 1964 - usually observed on seaward beaches, but occasionally on lagoon beaches; April 1967 - lagoon beaches of Sibylla.

Numbers -- July 1952 - "...commonly seen, as many as 4 at a time" (Fosberg, 1966); October 1964 - very common, Sibylla 150, Kamome 100; April 1967 - Sibylla 3; number banded 1.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - seven (Table 1). This is a new specimen record for the atoll.

17) <u>Arenaria interpres</u> Ruddy Turnstone

Habitat -- July 1952 - along seaward beaches sometimes in association with tattlers and plover (Fosberg, 1966); October 1964 - on seaward and lagoon beaches usually in company of other shorebirds.

Numbers -- July 1952 - "a few seen . . . usually in twos or threes" (Fosberg, 1966); October 1964 - Sibylla 250, Kamome 200.
Status -- Migrant.

Specimen Records - none.

18) <u>Crocethia alba</u> Sanderling

Habitat -- 11 October 1964 - Beach of Sibylla.

Numbers -- 11 October 1964 - Sibylla 1.

Status -- Migrant.

Specimen Records -- none. This sight record, however, constitutes a new bird species record for the atoll.

19) <u>Sterna sumatrana</u> Black-naped Tern

Habitat -- October 1964 - frequented islets between Breje and Sibylla and between Sibylla and Pokak; April 1967 - not seen on Sibylla.

Numbers -- October 1964 - Sibylla 25.

Status -- Resident breeder? October 1964 - no nests found; however, adult behavior indicated that nests might be present.

Specimen Record -- Other - none; POBSP - four (Table 1). These Black-naped Terns represent a new atoll species and specimen record.

20) Sterna lunata Gray-backed Tern

Habitat -- July 1952 - North Island only, "flushed with some reluctance from their resting places on the ground in the interior of this barren rocky islet" (Fosberg, 1966); April 1967 - observed flying over lagoon side of Sibylla.

Numbers -- July 1952 - small numbers seen on North Island (Fosberg, 1966); April 1967 - Sibylla two observed.

Status -- Resident breeder? Not breeding at time of visits, but there is a good chance this species does breed on Taongi Atoll, since it nests on Wake Island, 300 miles to the north.

Specimen Records -- None.

21) Sterna fuscata Sooty Tern

Habitat -- July 1952 - only on Kamome, rookeries (one to several acres in size) more commonly in the open part of the island, but also in sparse Tournefortia scrub (Fosberg, 1966); October 1964 - Kamome, concentrated on the northwest side, nests among the bunchgrass next to the lagoon beach and underneath the 3-4 foot high Sida which adjoins the bunchgrass; observed flying over all other islands; April 1967 - observed flying over Sibylla, probably on Kamome.

Numbers -- November 1951 - one pair flying around the ship near Taongi Atoll, July 1952 - most abundant bird on Taongi (Fosberg, 1966); October 1964 - Kamome, 15-20,000; April 1967 - 100's flying over Sibylla; number banded 2,091.

Status -- Resident breeder. July 1952 - few eggs, many young in all stages of development (Fosberg, 1966); October 1964 - eggs to large young; April 1967 - Sibylla, adults and immatures flying to and from Kamome.

Specimen Records -- Other - none; POBSP - 11 (Table 1). These Sooty Tern specimens represent the first museum specimens from Taongi Atoll.

22) Thalasseus bergii Crested Tern

Habitat -- July 1952 - patrolling the shallow water, diving for small fish (Fosberg, 1966); October 1964 - frequently seen on, or flying over, lagoon beaches and exposed reefs, nests placed high up on sandy lagoon beach at north end of Sibylla near bunches of Sesuvium; April 1967 - same as in 1964.

Numbers -- July 1952 - commoner than elsewhere, one to six could be seen at any time of the day (Fosberg, 1966); October 1964 - Sibylla 25-30; April 1967 - Sibylla 125.

Status -- Resident breeder. July 1952 - not breeding (Fosberg, 1966); October 1964 - Sibylla, seven nest scrapes, each containing an egg, were observed; April 1967 - Sibylla, 51 nests (49 with one egg, 2 with small young) in a single colony.

Specimen Records -- Other - none; POBSP - three (Table 1). This constitutes a new specimen record for the atoll.

23) Procelsterna cerulea Blue-gray Noddy

Habitat -- July 1952 - seaward side of Sibylla, Breje, and Pokak, all over North and Kamome, prefers open, unvegetated gravel ridges (Fosberg, 1966); October 1964 - observed only on sparsely vegetated islets between Breje and Sibylla; April 1967 - observed flying offshore on east side of atoll only.

Numbers -- July 1952 - "Small numbers are to be seen almost anywhere" (Fosberg, 1966); October 1964 - Sibylla (north end) 10; April 1967 - a few offshore.

Status -- Resident breeder. July 1952 - "One bird was flushed from a small empty nest, merely a slight accumulation of grass stems and feathers in a slight depression sheltered by two rocks on the boulder ridge on the seaward beach of Breje" (Fosberg, 1966); October 1964 - no nests observed, but adult behavior suggested nesting; April 1967 - no evidence of breeding.

Specimen Records -- None.

24) Anous stolidus Brown Noddy

Habitat -- July 1952 - on all islands; nests most commonly on Kamome in shrubs, on grass tufts, rocks, and on the ground; tends to sit in groups on exposed sandbars and rubble flats in the lagoon (Fosberg, 1966); October 1964 - frequents beaches of all islands; nests only on Kamome, mostly on the ground but also on rocks; April 1967 - observed on beaches and flying above Sibylla.

Numbers -- July 1952 - "common but by no means abundant" (Fosberg, 1966); October 1964 - Sibylla 100, Kamome 200, Breje present; April 1967 - Sibylla 50.

Status -- Resident breeder. July 1952 - nests with eggs (Fosberg, 1966); October 1964 - Kamome, nests with eggs and half-grown young; April 1967 - Sibylla, no evidence of breeding.

Specimen Record -- Other - none; POBSP-one (Table 1). This is a new specimen record for the atoll.

25) _Anous tenuirostris_ Black Noddy

Habitat -- July 1952 - seen occasionally fishing in the lagoon or just outside, nests in _Pisonia_ trees on Kamome (Fosberg, 1966); October 1964 - frequents beaches of all islands, roosts and nests mainly in _Messerschmidia_; April 1967 - Sibylla, observed on beaches, nests in _Messerschmidia_.

Numbers -- July 1952 - seen occasionally; less plentiful than the Brown Noddy (Fosberg, 1966); October 1964 - Sibylla 25, Kamome 100; April 1967 - Sibylla 50.

Status -- Resident breeder. July 1952 - small groups of nests present on Kamome, "but it was not noted whether there were eggs" (Fosberg, 1966); October 1964 - few nests present with eggs and small young; April 1967 - Sibylla, few nests with eggs.

Specimen Records -- None.

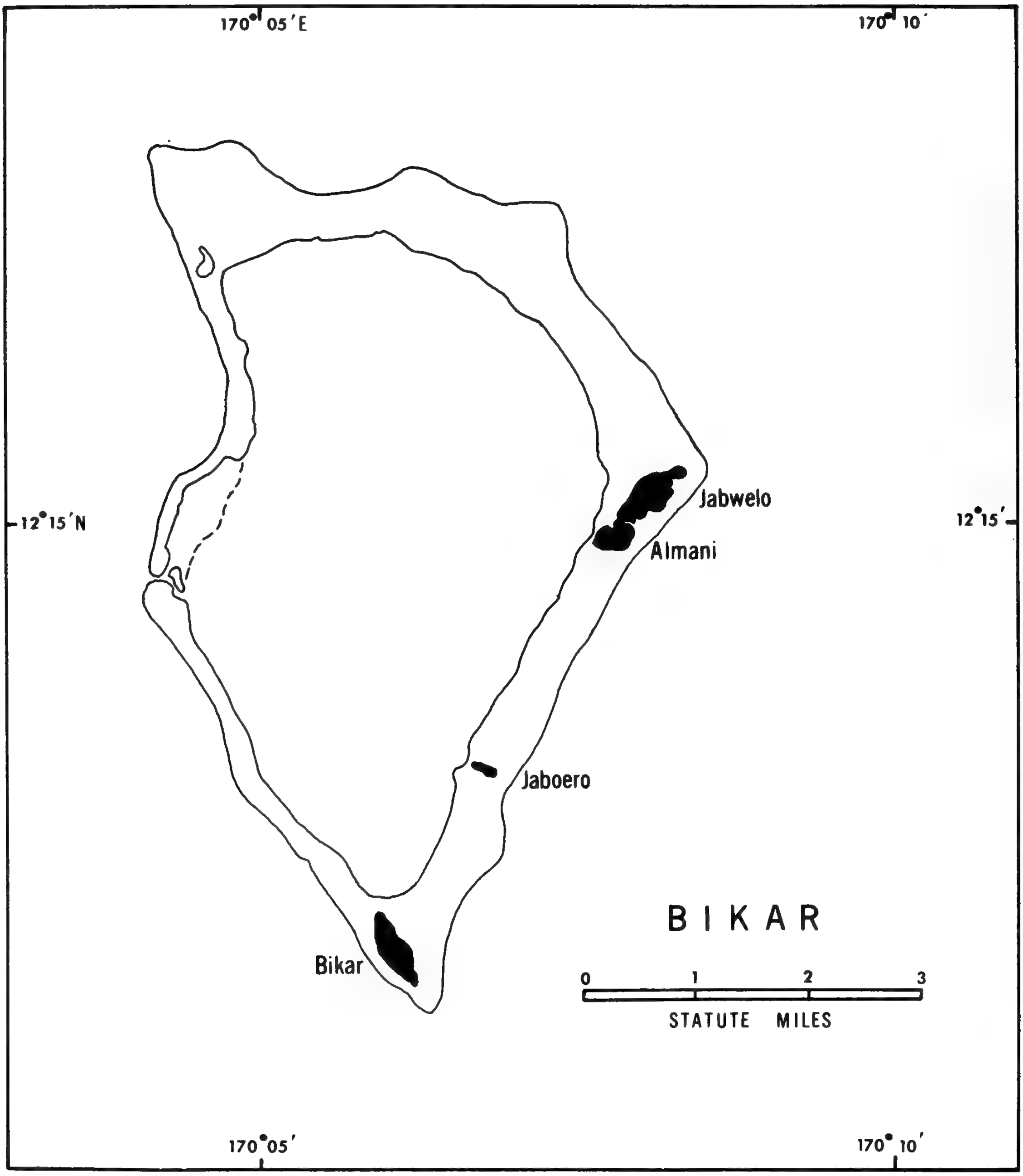
26) _Gygis alba_ White Tern

Habitat -- November 1951 and March 1952 - flew around the ship, July 1952 - seen on all islets, over the lagoon, and surrounding ocean, nests in _Tournefortia_ and _Pisonia_ trees and on boulders (Fosberg, 1966); October 1964 - on all islands, roosts and nests in most bushes and trees; April 1967 - roosting and nesting in _Messerschmidia_ bushes on Sibylla.

Numbers -- July 1952 - "home of great numbers" (Fosberg, 1966); October 1964 - Sibylla 200, Kamome 200+, North 200+; April 1967 - Sibylla 500; number banded 16.

Status -- Resident breeder. July 1952 - eggs present on Kamome and South (Fosberg, 1966); October 1964 - few eggs and young on Sibylla; many with eggs and chicks (all stages) on Kamome; April 1967 - few small chicks on Sibylla Island.

Specimen Records -- Other - none; POBSP - two (Table 1). This constitutes a new specimen record for Taongi Atoll.



170° 05′E
170° 10′
12° 15′N
12° 15′
Jabwelo
Almani
Jaboero
Bikar
BIKAR
0
1
2
3
STATUTE MILES
170° 05′
170° 10′

BIKAR ATOLL

Location: 12°15' N x 170°06' E.

Shape and Size: Diamond-shaped; Tip to tip (north-south) - 8 miles; Widest point (east-west) - 5 miles; Total lagoon area - 21.82 square miles; Total dry land area - 0.20 square miles; Number of islands - 6; Height - 15± feet (Fosberg, 1956).

Soil: Beach (ocean side) - mostly coral rock, some sand; Beach (lagoon side) - mostly sand, some rocky and cobble-stone areas.

Vegetation: Nine species, three principal islands densely wooded with *Pisonia* trees, with a fringe of *Messerschmidia* around the outside (Fosberg, 1955, 1956).

Climate: Moderately dry, about 40-50 inches of rainfall yearly; Mean air temperature - 82° F; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - not inhabited, but occasionally visited by Marshallese who regarded it as a bird refuge (Fosberg, 1957); Present - not inhabited, but evidence of 1964 shipwreck (NoHo Maru No. 11) in the north fork of the reef passage.

Scientific Visits: Japanese visit (S. Kawakami) 30 January and 10 July 1932; Northern Marshall Islands Expedition - 26 November 1951 (examined only from ship), 24 March 1952 (examined only from ship), 6-12 August 1952; POBSP - 14-19 October 1964, 7 May 1967.

Avifauna: Twenty-three bird species are presently known from Bikar Atoll. These include 17 seabirds, 5 shorebirds, and 1 heron. Thirteen of these species are known breeders, three others are possible breeders, five are migrants, one is a visitor, and another is an accidental.

Bikar Atoll is the only known locality in the Marshall and Gilbert Islands from which *Sterna anaetheta* has been recorded.

Twenty-three species are listed in the following checklist, which was derived from various sources: (1) POBSP, (a) 1964, (b) 1967; (2) Fosberg, (a) 1955, (b) 1966; (3) Finsch, 1880d; (4) Yamashina, 1940; (5) Handlist Japanese Birds, 1958; (6) Baker, 1951; and (7) YIZM collection. These sources are referred to in the checklist by corresponding numbers and letters. The four species marked by a single asterisk are new species records for Bikar Atoll; the two species marked by a double asterisk are new atoll breeding records.

Bikar Atoll Avifauna Checklist

	Species	Status	Source
1)	Puffinus pacificus*	Resident breeder**	1a
2)	Puffinus nativitatus*	Visitor ?	1b
3)	Phaethon rubricauda	Resident breeder	1ab, 2b, 3
4)	Phaethon lepturus	Resident breeder	1ab, 2ab, 3
5)	Sula dactylatra	Resident breeder	1ab, 2b, 3
6)	Sula sula	Resident breeder	1ab, 2b, 3, 7
7)	Sula leucogaster	Resident breeder	1ab, 2b, 3
8)	Fregata minor	Resident breeder	1ab, 2b, 3, 4, 5, 7
9)	Egretta sacra*	Resident breeder ?	1ab
10)	Pluvialis dominica	Migrant	1ab, 2b
11)	Numenius tahitiensis	Migrant	1ab, 2b
12)	Heteroscelus incanum	Migrant	1ab, 2b
13)	Arenaria interpres	Migrant	1ab, 2b
14)	Crocethia alba*	Migrant	1a
15)	Sterna sumatrana	Resident breeder ?	1ab, 2b
16)	Sterna lunata	Resident breeder ?	2b
17)	Sterna anaetheta	Accidental	4, 6, 7
18)	Sterna fuscata	Resident breeder	1ab, 2b
19)	Thalasseus bergii	Resident breeder**	1ab, 2b
20)	Procelsterna cerulea	Resident breeder	1ab, 2b, 7
21)	Anous stolidus	Resident breeder	1ab, 2b
22)	Anous tenuirostris	Resident Breeder	1ab, 2b
23)	Gygis alba	Resident Breeder	1ab, 2b

POBSP personnel have collected 48 specimens of 16 species (Table 2). Of these 16 species, 1 is a specimen record of a species not previously known from Bikar Atoll, and 12 represent the first specimen confirmation of species previously known only from sight records. Thirteen specimens of four species collected at Bikar Atoll (Table 3) are located at the Yamashina Institute of Zoology and Ornithology Museum in Tokyo, Japan. Combined museum collections total 61 specimens of 17 species.

Species Accounts

1) Puffinus pacificus — Wedge-tailed Shearwater

Habitat -- October 1964 - Almani only, nesting in bunch-grass area on east side of island.

Numbers -- October 1964 - Almani, 6 seen.

Status -- Resident breeder. October 1964 - 2 nests each with a nearly fledged chick. This represents a new breeding record.

TABLE 2. Bird specimens collected by POBSP on Bikar Atoll

Species	Museum		Sex	Age	Location	Date	Status	Collector
Puffinus pacificus	USNM	494819	♂		Almani	10-17-64	Skin	Huber
Phaethon rubricauda	"	543460	♂	A	Bikar I	5 -7-67	"	Amerson
" "	"	543459	♂	A	Almani	"	"	"
Phaethon lepturus	"	494864	♂		"	10-18-64	"	Huber
Sula dactylatra	"	543345	♀	A	"	5-7-67	"	Amerson
" "	"	543346	♂	A	"	"	"	"
Sula sula	"	497990	♂		"	10-17-64	Skel.	"
" "	"	497991	?	I	"	"	"	Huber
" "	"	543466	♂	A	Bikar I	5-7-67	Skin	Amerson
" "	"	543467	♂	A	"	"	"	"
" "	"	543468	♂	A	Jabwelo	"	"	"
" "	"	543469	♂	A	Almani	"	"	"
" "	"	543353	♂	I	"	"	"	"
Sula leucogaster	"	543465	♂	A	Bikar I	"	"	"
Fregata minor	"	543381	♂	A	"	"	"	"
" "	"	543382	♀	A	Almani	"	"	"
Numenius tahitiensis	"	543456	♀	-	Bikar I	"	"	"
Heteroscelus incanum	"	495891	♀	-	"	10-15-64	"	Huber
Arenaria interpres	"	494758	♂	-	"	"	"	"
" "	"	495912	♀	-	"	"	"	"
" "	"	495913	♀	-	"	"	"	"
" "	"	495914	♀	-	"	"	"	"
" "	"	495915	♀	-	"	"	"	"
Sterna fuscata	"	494701	♀	-	Jabwelo	10-18-65	"	Amerson & Amerman
" "	"	494702	♀	-	"	"	"	"
" "	"	494703	♂	-	"	"	"	"
" "	"	494704	♀	-	"	"	"	Huber
" "	"	494705	♂	-	"	"	"	"
" "	"	494706	♂	-	"	"	"	"
" "	"	543497	?	Nest	Almani	5-7-67	"	Amerson
" "	"	543488	♀	A	"	"	"	"
" "	"	543489	?	A	"	"	"	"
" "	"	543490	♂	A	"	"	"	"
" "	"	543491	♂	A	Jabwelo	"	"	"
" "	"	543492	♂	A	"	"	"	"
" "	"	543493	♂	A	"	"	"	"
" "	"	543495	♀	A	Almani	"	"	"
Thalasseus bergii	"	494729	♀	A	Bikar I	10-15-64	"	Huber
" "	"	494730	♂	Chick	Jabwelo	10-17-64	"	Amerson
" "	"	543454	♀	A	Bikar I	5-7-67	"	"

TABLE 2. Bird specimens collected by POBSP on Bikar Atoll (cont'd)

Species	Museum	Sex	Age	Location	Date	Status	Collector
Procelsterna cerulea	USNM 494741	♀	A	Almani	10-17-64	Skin	Huber
" "	" 494742	♀	A	"	"	"	"
" "	" 543453	♂	A	"	5-7-67	"	Amerson
Anous stolidus	" 543478	♂	A	Jabwelo	"	"	"
" "	" 543479	♂	A	Almani	"	"	"
Anous tenuirostris	" 543447	♂	A	"	"	"	"
Gygis alba	" 494610	♂	-	Bikar I	10-15-64	"	"
" "	" 543451	♂	A	Almani	5-7-67	"	"

TABLE 3. Bird specimens collected from Bikar Atoll in the Yamashina Collection

Species	Museum	Sex	Age	Location	Date	Status	Collector
Sula sula	YIZM	♀	Juv	Bikar	07-10-32	Skin	S. Kawakami
" "	"	♀	"	"	"	"	"
" "	"	♀	"	"	"	"	"
Fregata minor	"	♀	A	"	"	"	"
Sterna anaetheta	"	♀	Juv	"	01-30-32	"	"
Procelsterna cerulea	"	♂	-	"	07-10-32	"	"
" "	"	♂	-	"	"	"	"
" "	"	♂	-	"	"	"	"
" "	"	♂	-	"	"	"	"
" "	"	♂	-	"	"	"	"
" "	"	♀	-	"	"	"	"
" "	"	♀	-	"	"	"	"
" "	"	♀	-	"	"	"	"

Specimen Records -- Other - none; POBSP - one (Table 2). This is a new bird species and specimen record for Bikar Atoll.

2) Puffinus nativitatus Christmas Shearwater

Habitat -- May 1967 - observed flying low over seaward rocky beach of Bikar Island, not seen on the other islands.

Numbers -- May 1967 - Bikar Island 1.

Status -- Visitor? May 1967 - No evidence of breeding (all islands were searched for nests) although it may breed here.

Specimen Records -- None. This sighting constitutes a new species sight record from the atoll.

3) Phaethon rubricauda Red-tailed Tropicbird

Habitat -- August 1952 - flying over the north end of Bikar Island (Fosberg, 1966); October 1964 - flying over and nesting on all three main islands in the atoll, nests placed under Scaevola and Messerschmidia bushes around the edges of each island(some inland, however); May 1967 - flying over and nesting under Scaevola and Messerschmidia on all three main islands.

Numbers -- August 1952 - small groups of several to a dozen birds over Bikar Island (Fosberg, 1966); October 1964 - Bikar 25, Jabwelo and Almani 100; May 1967 - Bikar 25, Almani 35, Jabwelo 50; number banded - 26.

Status -- Resident breeder. 1880 - see under Phaethon lepturus; August 1952 - no nesting observed (Fosberg, 1966); October 1964 - Bikar one nest with an egg seen, Jabwelo and Almani 22 nests (all with some eggs except for three with downy chicks);May 1967 - eggs to fledglings on all islands visited.

Specimen Records -- Other - none; POBSP - two (Table 2). This is a new specimen record for the atoll.

4) Phaethon lepturus White-tailed Tropicbird

Habitat -- August 1952 - flying round and round in openings in dense Pisonia forest of Bikar Island, nest found about 7 meters high in a hole in a large Pisonia tree (Fosberg, 1955, 1966); October 1964 - flying (displaying) over all three vegetated islands; nests 3 to 20 feet high in holes of Pisonia trees on Jabwelo Island; May 1967 - flying over Jabwelo.

Numbers -- August 1952 - 3 or 4 were seen at a time on Bikar Island (Fosberg, 1966); October 1964 - Bikar 10, Jabwelo and Almani 30-40; May 1967 - Jabwelo one seen; number banded - 6.

Status -- Resident breeder. 1880 - "...Tropicbirds, I was assured, breed in great numbers on Bigar [Bikar], on uninhabited and nearly barren islands, the northernmost of the Ratak chain..." (Finsch, 1880); August 1952 - nest present on Bikar Island but status unknown (Fosberg, 1966); October 1964 - six nests (one with an egg and another with a small chick) found on Jabwelo and Almani, probably also nests on Bikar; May 1967 - no nests seen, but possibly nesting on Jabwelo.

Specimen Records -- Other - none; POBSP - one (Table 2). This specimen,caught at its nest site, represents the only White-tailed Tropicbird collected from Bikar Atoll.

5) Sula dactylatra Blue-faced Booby

Habitat -- March 1952 - seen fishing with other boobies, noddies, and White Terns, August 1952 - nesting on the ground, especially on Jaliklik (Jabwelo) (Fosberg, 1966); October 1964 - Bikar, flying over, Almani, few nests and a large club roosting on east (seaward) side, Jabwelo nesting on south grassy area; May 1967 - Bikar, roosting, Almani and Jabwelo, nesting on open ground.

Numbers -- March 1952 - a few seen, August 1952 - small numbers were nesting (Fosberg, 1966); October 1964 - Bikar 2, Jabwelo and Almani 300; May 1967 - Bikar 2, Almani 20, Jabwelo 50, lagoon 2; number banded 106.

Status -- Resident breeder. 1880 - "... and Boobies (Sula [sp.?]), I was assured, breed in great numbers on Bigar [Bikar] ..." (Finsch, 1880d);August 1952 - small numbers nesting, quite a few young in all stages of development (Fosberg, 1955, 1966); October 1964 - 32 nests (all with eggs except one with a chick) only on Jabwelo and Almani; May 1967 - eggs to fledglings on Jabwelo and Almani.

Specimen Records -- Other - none; POBSP - two (Table 2). This constitutes a new specimen record for the atoll.

6) Sula sula Red-footed Booby

Habitat -- November 1951 - several seen flying, March 1952 - seen near the atoll fishing with other species of boobies, noddies, and White Terns, also roosting in trees, August 1952 - seen at almost any time of day roosting in Pisonia trees, or flying about when disturbed, nests high in Pisonia trees (Fosberg, 1966); October 1964 - flying above and roosting on Bikar, Jabwelo, and Almani, nests in tops of Pisonia trees on Bikar; May 1967 - roosting and nesting in tops of Pisonia trees on Bikar, Jabwelo, and Almani.

Numbers -- March 1952 - considerable numbers near the atoll, August 1952 - large numbers were seen (Fosberg, 1966); October 1964 -

Bikar 200, Jabwelo and Almani 1000+;May 1967 - Bikar 200, Almani 300, Jabwelo 500, lagoon 20; number banded 376.

Status -- Resident breeder. 1880 - see under Sula dactylatra; August 1952 - "a few nests were spotted...with old birds sitting on them, or with almost mature young " (Fosberg, 1966); October 1964 - few nests on Bikar Island; May 1967 - half-grown young to fledglings on Bikar, Almani, and Jabwelo.

Specimen Records -- Other - three (Table 3); POBSP - six (Table 2).

7) Sula leucogaster Brown Booby

Habitat -- March 1952 - flying along seaward beaches and fishing in company with other boobies, noddies, and White Terns, August 1952 - "... seen flying and resting on trees on low branches and shrubs, as well as on the ground." "One bird was frightened off a nest about 4 meters up in a Pisonia tree, but identification was not certain, and it may well have been a dark phase of the Red-footed Booby." (Fosberg, 1966); October 1964 - roosting around the edges of the three vegetated islands; May 1967 - nesting on the ground under and near the higher vegetation on Bikar, Jabwelo, and Almani.

Numbers -- March 1952 - seen commonly, August 1952 - many were seen (Fosberg, 1966); August 1964 - Bikar 10, Jabwelo and Almani 200; May 1967 - Bikar 100, Almani 200, Jabwelo 300, lagoon 30; number banded 178.

Status -- Resident breeder. 1880 - see under Sula dactylatra; August 1952 - none were seen nesting (Fosberg, 1966); October 1964 - one old nest seen, courtship behavior observed; May 1967 - half-grown young to fledglings present on Bikar, Almani, and Jabwelo.

Specimen Records -- Other - none; POBSP - one (Table 2). This collection represents a new specimen record for Bikar Atoll.

8) Fregata minor Great Frigatebird

Habitat -- March 1952 - roosting in trees, August 1952 - roosting in trees and flying over the atoll (Fosberg, 1966); October 1964 - occurs on Bikar, Jabwelo, and Almani, roosting in tops of Pisonia trees; May 1967 - roosts and nests in tops of Pisonia trees at Bikar, Jabwelo, and Almani.

Numbers-- 1880 - "Frigate-birds ..., I was assured, breed in great numbers on Bigar [Bikar] ..." (Finsch, 1880d);[Baker (1951), Yamashina (1940), and Hand-list Japanese Birds (4th ed., 1958) list this species as occurring on Bikar Atoll;] November 1951 - 6

frigatebirds (Fosberg, 1966), March 1952 - many roosting, great swarms scared up by ship's whistle (Fosberg, 1966); August 1952 - seen in large numbers (Fosberg, 1966); October 1964 - Bikar 200, Jabwelo and Almani 750; May 1967 - Bikar 100, Almani 100, Jabwelo 100, lagoon 25; number banded 11.

Status -- Resident breeder. 1880 - breeding (Finsch, 1880); August 1952 - "a few immature ones were seen in Pisonia trees" (Fosberg, 1966); October 1964 - not nesting, courtship behavior observed; May 1967 - half-grown young to fledglings on Bikar, Jabwelo, and Almani.

Specimen Records -- Other - one (Table 3); POBSP - two (Table 2).

9) Egretta sacra — Reef Heron

Habitat -- October 1964 - along exposed reef at low tide, lagoon beach area, one observed roosting in palm tree; May 1967 - on beach rock at Bikar and Jabwelo.

Numbers -- October 1964 - uncommon; Bikar 4, Jaboero 1, Jabwelo and Almani 1; May 1967 - Bikar 1, Jabwelo 1.

Status -- Resident breeder? No evidence of breeding; however, there is a possibility that it breeds here.

Specimen Records -- None. These sightings constitute a new bird species record for Bikar Atoll.

10) Pluvialis dominica — Golden Plover

Habitat -- August 1952 - "... commonly seen on all islets, especially around the edges, on beaches and reef flats ..." (Fosberg, 1966); October 1964 - seen on all islands, on beaches, and occasionally inland; May 1967 - observed on beaches of Bikar, Jabwelo, and Almani.

Numbers -- August 1952 - "single individuals, and rarely, small flocks of up to 7 birds ..." (Fosberg, 1966); October 1964 - Bikar 25, Jaboero 10, Jabwelo and Almani 20; May 1967 - Bikar 1, Almani 1, Jabwelo 3; number banded 1.

Status -- Migrant.

Specimen Records -- None.

11) Numenius tahitiensis — Bristle-thighed Curlew

Habitat -- August 1952 - on rock flats and ground beaches (Fosberg, 1966); October 1964 - on sandy and rocky beaches and tidal flats; May 1967 - on all beach areas.

Numbers -- August 1952 - "single individuals, two or three at a time, were commonly seen ..." (Fosberg, 1966); October 1964 - Bikar 10, Jaboero 1, Jabwelo and Almani 5; May 1967 - Bikar 2, Almani 2, Jabwelo 3; number banded 1.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - one (Table 2). This constitutes a new specimen record from Bikar Atoll.

12) Heteroscelus incanum Wandering Tattler

Habitat -- August 1952 - "... seen on beaches and reef flats, especially on seaward side of islets" (Fosberg, 1966); October 1964 - sandy and rocky seaward beaches; May 1967 - on seaward beaches of Bikar and Jabwelo.

Numbers -- August 1952 - "... 1 to 3 or rarely 4 ... were occasionally seen ..." (Fosberg, 1966); October 1964 - Bikar 5, Jaboero 5, Jabwelo and Almani 5; May 1967 - Bikar 1, Jabwelo 1.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - one (Table 2). This is a new specimen record from Bikar Atoll.

13) Arenaria interpres Ruddy Turnstone

Habitat -- August 1952 - on beaches, reef flats, and rock flats (Fosberg, 1966); October 1964 - seen on sandy and rocky beaches and occasionally in the center of the Pisonia forest; May 1967 - on beaches.

Numbers-- August 1952 - "single individuals, pairs, and small flocks of up to half a dozen were occasionally seen ..." (Fosberg, 1966); October 1964 - Bikar 30, Jaboero 25, Jabwelo and Almani 50; May 1967 - Bikar 5, Almani 10, Jabwelo, 10, flying over lagoon 1.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - five (Table 2). These five specimens are the first Ruddy Turnstones to be collected from Bikar Atoll and constitute a new specimen record.

14) Crocethia alba Sanderling

Habitat -- October 1964 - Jaboero, seen with flock of Ruddy Turnstones and Golden Plovers on rocky beach.

Numbers -- 16 October 1964 - one seen at Jaboero.

Status -- Migrant.

Specimen Records -- None. This sight record is a new species record for Bikar Atoll.

15) Sterna sumatrana Black-naped Tern

Habitat -- August 1952 - "... seen flying over or resting on open gravel bars and beach rock, especially between Alnemi[Almani] and Jaliklik [Jabwelo] Islets." (Fosberg, 1966); October 1964 - frequents sandy and rocky beach areas of Jaboero, Almani, and Jabwelo; May 1967 - on rocky portion of Bikar and flying over the lagoon.

Numbers -- August 1952 - "... small groups of 3 to 10 ... between Almeni [Almani] and Jaliklik [Jabwelo] Islets" (Fosberg, 1966); October 1964 - Jaboero 4, Jabwelo and Almani 15-20; May 1967 - Bikar 3, lagoon 4.

Status --Resident breeder? August 1952 - not listed as breeding (Fosberg, 1966); October 1964 and May 1967 - no evidence of breeding. This species probably does, however, breed in small numbers at Bikar Atoll.

Specimen Records -- None.

16) Sterna lunata Gray-backed Tern

Habitat -- August 1952 - flying over north end of Bikar Island (Fosberg, 1966).

Numbers -- August 1952 - one bird seen (Fosberg, 1966).

Status -- Resident breeder? Not recorded as breeding from Bikar Atoll.

Specimen Records -- None.

17) Sterna anaethetas Brown-winged Tern

Habitat -- July 1932 - on Bikar (Yamashina, 1940; Baker, 1951).

Numbers -- July 1932 - one collected.

Status -- Accidental. July 1932 - Unknown. The collected specimen was listed by Yamashina (pers. corresp., 1966) as a juvenal bird. It is not known whether the specimen is a hatchling or young bird in juvenal plumage. If the latter is true, this species was probably not breeding on Bikar Atoll.

Specimen Records -- Other - one (Table 3); POBSP - none. This is the only known record for this species in the Marshall and Gilbert Islands.

18) _Sterna fuscata_ Sooty Tern

Habitat -- August 1942 - "... flying almost anywhere on Bikar Atoll, nesting on Jaboero (a small gravel bar sparsely covered with _Portulaca lutea_) nesting on rock flats seaward of Almeni [Almani] and Jaliklik [Jabwelo] Islets and on the northeast extension of Jaliklik [Jabwelo] (Fosberg, 1966); October 1964 - concentrated around Jabwelo; active nesting area northeast of main island on rock flat, old nesting area south portion on grassy open area; May 1967 - flying over Bikar, active nesting colonies on grassy south portion of Jabwelo and on open, rocky, east portion of Almani.

Numbers -- August 1952 - seen commonly flying almost anywhere, thousands of pairs on Jaboero, small rookery on Almani and Jabwelo (Fosberg, 1966); October 1964 - Jabwelo 5000+ adults, 2500+ nestlings; May 1967 - Almani 12,000 adults, 5,000 nestlings, Jabwelo 25,000 adults, 10,000 nestlings; number banded 1400.

Status -- Resident breeder. August 1952 - Jaboero rookery of thousands of pairs, hundreds of eggs, thousands of newly hatched chicks (quite a few dead), rock flats seaward of Almani and Jabwelo scattered with eggs and shells, northeast extension of Jabwelo was small rookery with many young birds with wings feathered out (Fosberg, 1966); October 1964 - 5,000 adults, 2,500 chicks (mostly 10-20 days old), no fresh eggs and many broken eggs on northeast section of Jabwelo; many dead (skeletons only) chicks on grassy open area of south Jabwelo (adults circling over the latter area from 1300 to 0100 hours may be a different breeding population than those on northeast portion); May 1967 - almost fledged young to fledglings on both Almani and Jabwelo.

Specimen Records -- Other - none; POBSP - 14 (Table 2). These specimens represent a new specimen record from Bikar Atoll.

19) _Thalasseus bergii_ Crested Tern

Habitat -- August 1952 - "... seen occasionally flying over reef flats ..." (Fosberg, 1966); October 1964 - flying over and roosting on exposed reef, seaward and lagoon beach areas; nesting only on coral rock in center of Sooty Tern colony on northeast section of Jabwelo; May 1967 -roosting and nesting on the south rocky area of Bikar, flying over and roosting on the rocky seaward portions of Almani and Jabwelo.

Numbers -- August 1952 - "... pairs or single birds were seen occasionally ..." (Fosberg, 1966); October 1964 - Bikar 25, Jaboero 1, Jabwelo and Almani 50; May 1967 - Bikar 17, Almani 2, Jabwelo 4,flying over lagoon 2.

Status -- Resident breeder. August 1952 - not listed as breeding by Fosberg (1966); October 1964 - 20 eggs and 2 small chicks in an oval area, nesting density about 1 nest/2 square feet. Nest description - slight scooped depression (diameter about 6 inches, depth about .5 to 1.5 inches) in the coarse rubbly coral and sand; May 1967 - Bikar 7 nests with eggs. This is a new breeding record for Bikar Atoll.

Specimen Records -- Other - none; POBSP - three (Table 2). Although Crested Terns have been observed from Bikar Atoll earlier, these three specimens represent the first collected specimen records from the atoll.

20) Procelsterna cerulea Blue-gray Noddy

Habitat -- July 1932 - Bikar (Yamashina, 1940 and Baker, 1951); August 1952 - flitting over gravel bars and flats on Jabwelo, nest (a few grass culms in a very slight depression) on a gravel bar between Almani and Jabwelo (Fosberg, 1966); October 1964 - only around coral rock and sand area connecting Jabwelo and Almani; May 1967 - observed flying around rocky and open grass areas on the seaward side of Almani and Jabwelo.

Numbers -- July 1932 - Bikar 8 (Yamashina, pers. corresp., 1966); August 1952 - Jabwelo 3 solitary individuals seen (Fosberg, 1966); October 1964 - Jabwelo and Almani 20, absent on other islands; May 1967 - Bikar 0, Jabwelo 4, Almani 2; number banded 1.

Status -- Resident breeder. August 1952 - Almani and Jabwelo one nest with an egg on gravel bar; October 1964 - no evidence of nesting; May 1967 - collected specimen had bare brood patch.

Specimen Records -- Other - eight (Table 3); POBSP - three (Table 2).

21) Anous stolidus Brown Noddy

Habitat -- August 1952 - nests in crotches of Pisonia trees Jabwelo (Fosberg, 1966); October 1964 - in Pisonia forest on Jabwelo; May 1967 - nests placed in crotches of Pisonia and Messerschmidia on all three major islands.

Numbers -- March 1942 - "... some noddies were seen flying, probably this species", August 1952 - Jabwelo four seen (Fosberg, 1966); October 1964 - not common, Jabwelo three seen; May 1967 - very common, Bikar 200, Almani 200, Jabwelo 300, flying over lagoon 5.

Status -- Resident breeder. August 1952 - two nests (Fosberg, 1966); October 1964 - no evidence of breeding; May 1967 - nests with eggs all three major islands.

Specimen Records -- Other - none; POBSP - two (Table 2). This represents a new specimen record for Bikar Atoll.

22) Anous tenuirostris Black Noddy

Habitat -- August 1952 - Almani and Jabwelo, nests in Pisonia trees, infrequent outside the forest (Fosberg, 1966); October 1964 - on all three major vegetated islands, nesting in Pisonia trees, occasionally seen over lagoon; May 1967 - on Bikar, Almani, and Jabwelo, roosts and nests in tops of Pisonia, also over lagoon.

Numbers -- August 1952 - "... not plentiful, ... single bird and three nests ... on Almeni [Almani] Islet, ... small colony of a couple of dozen nests and a few birds ... on Jaliklik [Jabwelo] Islet, ... very few birds ... outside the forest, ... none ... on Bikar Islet" (Fosberg, 1966); October 1964 - Bikar 20, Jabwelo and Almani 40; May 1967 - Bikar 100, Almani 100, Jabwelo 200, flying over lagoon 10.

Status -- Resident breeder. August 1952 - Almani three nests, Jabwelo 24 nests (Fosberg, 1966); October 1964 - less than 10 active nests with eggs and young, many old nests present on all three major vegetated islands; May 1967 - nests with eggs on Bikar, Almani, and Jabwelo.

Specimen Records -- Other - none; POBSP - one (Table 2). This constitutes a new specimen record for the atoll.

23) Gygis alba White Tern

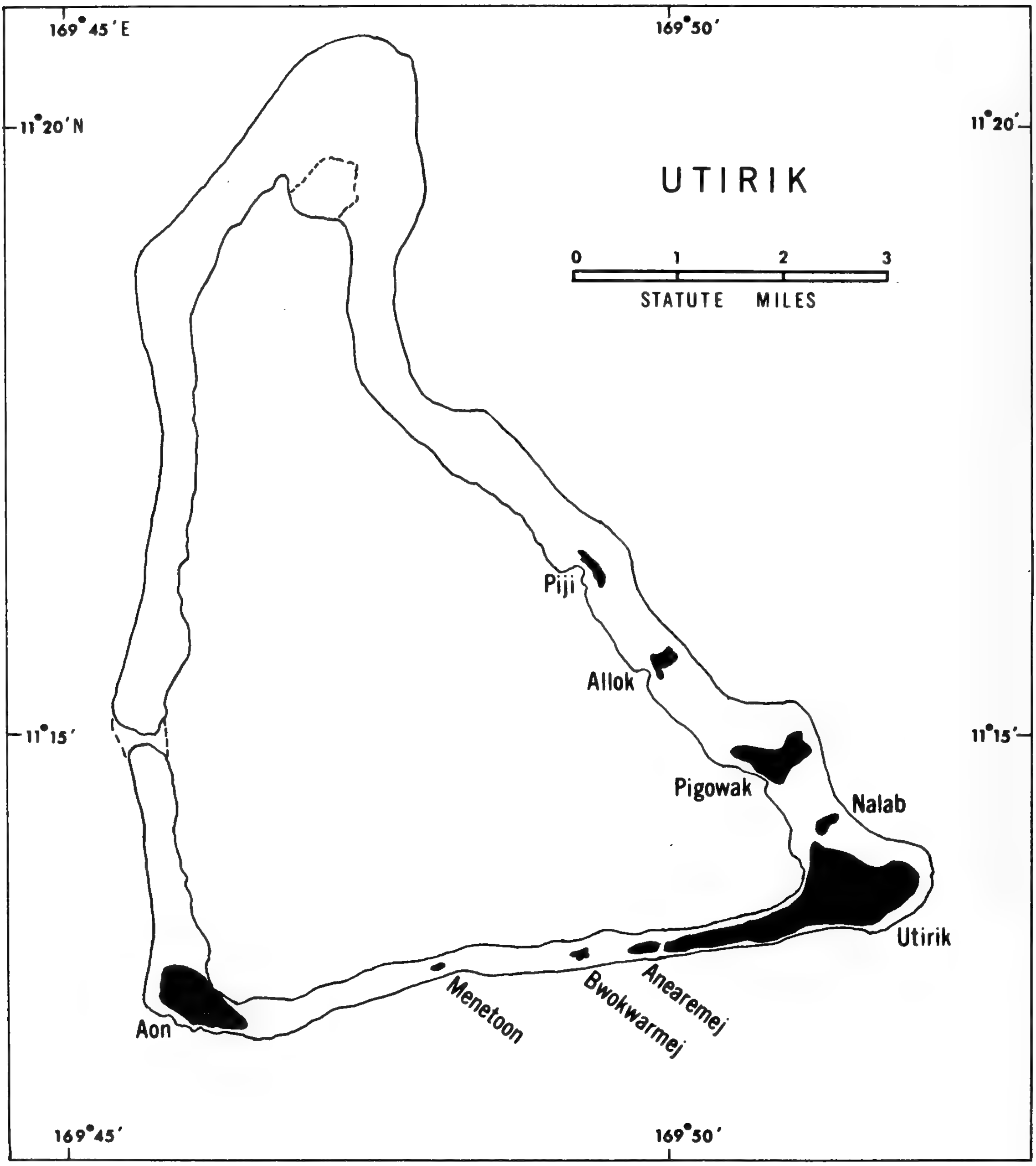
Habitat -- November 1951 - "... flying over all three islets ...", 24 March 1952 - "... flying over the north, east, and south sides ...", August 1952 - flying everywhere, especially over Pisonia trees on Almani Island, nests in the trees (Fosberg, 1966); October 1964 - flying over all islands and lagoon and surrounding ocean, roosting and nesting in Pisonia trees; May 1967 - flying about all islands and lagoon, roosting and nesting in Pisonia and Messerschmidia.

Numbers -- November 1951 - very common over all three islets, March 1952 - present, August 1952 - generally common, hundreds on Almani (Fosberg, 1966); October 1964 - Bikar 200, Jabwelo and Almani 300; May 1967 - Bikar 200, Almani 200, Jabwelo 300, over lagoon 4.

Status -- Resident breeder. August 1952 - few downy young present (Fosberg, 1966); October 1964 - nesting only on Jabwelo and Almani, a few eggs and downy chicks present; May 1967 - specimen collected had a bare brood patch.

Specimen Record -- Other - none; POBSP - two (Table 2). This is a new specimen record from Bikar Atoll.

348-415 O-69—4



UTIRIK
169°45′E
169°50′
11°20′N
11°20′
11°15′
11°15′
169°45′
169°50′
0
1
2
3
STATUTE MILES
Piji
Allok
Pigowak
Nalab
Utirik
Anearemej
Bwokwarmej
Menetoon
Aon

UTIRIK ATOLL

Location: 11°15' N x 169°48'E.

Shape and Size: Irregular triangle-shaped; North tip to south base - 9 miles; Width of base - 8 miles; Total lagoon area - 35.68 square miles; Total dry land area - 1.04 square miles; Number of islands - 8; Height - ? feet (Fosberg, 1956; Wiens, 1957).

Soil: Beach (ocean side) - mostly boulder ridges and cobblestone areas; Beach (lagoon side) - mostly sand areas; Interior - mostly sandy soil (Wiens, 1957).

Vegetation: Forty-nine species; Utirik Island mostly planted with *Cocos*; Other islands contain *Cocos* and scrub growth (Fosberg, 1956; Wiens, 1957).

Climate: Moderate rainfall, about 60-70 inches yearly; Mean air temperature-82° F.; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - not permanently inhabited (Findlay, 1886); 166 in 1948 (Freeman, 1951); Present - inhabited, 219 in 1964 (U.S. Department of State, 1965).

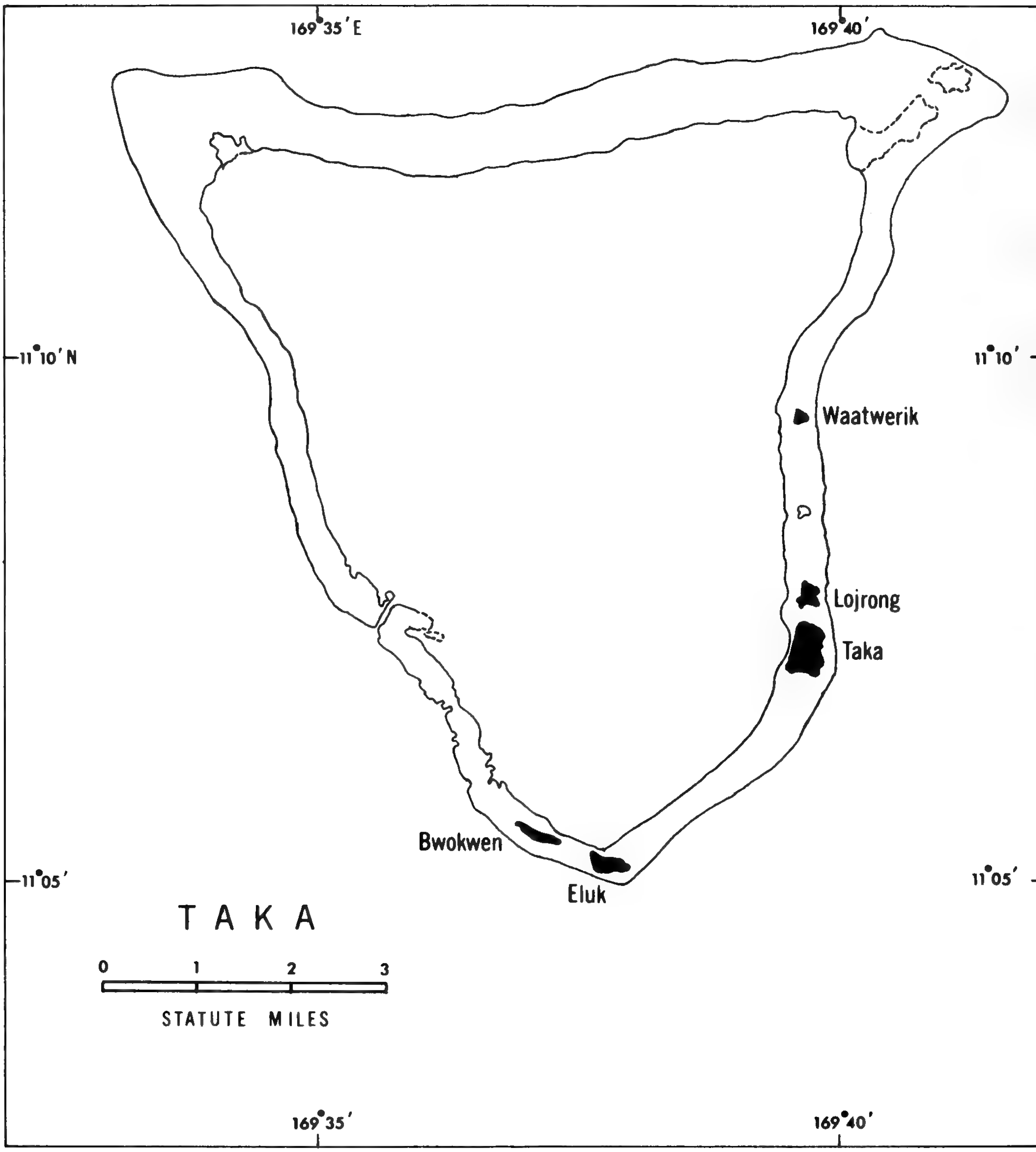
Scientific Visits: Northern Marshall Islands Expedition - 23 Nov-4 Dec. 1951; U.S. Navy - 13 February 1956; Pacific Science Board - summer 1956.

Avifauna: Ten bird species are known from Utirk Atoll. These include three seabird species, five shorebird species, and two domestic species (duck and fowl). Only one species is known to breed on the atoll, while four species are potential breeders; five species are migrants. No museum specimens are known from the atoll.

Ten species are listed in the following checklist, which was derived from two sources: (1) Fosberg, 1966; and (2) Kramer, 1938. These sources are referred to in the checklist by corresponding numbers.

Utirik Atoll Avifauna Checklist

	Species	Status	Sources
1)	*Phaethon lepturus*	Resident breeder ?	1
2)	*Cairina moschata*	Introduced breeder ?	1
3)	*Gallus gallus*	Introduced breeder ?	1, 2
4)	*Pluvialis dominica*	Migrant	1
5)	*Numenius phaeopus*	Migrant	1
6)	*Numenius tahitiensis*	Migrant	1
7)	*Heteroscelus incanum*	Migrant	1
8)	*Arenaria interpres*	Migrant	1
9)	*Thalasseus bergii*	Resident breeder ?	1
10)	*Gygis alba*	Breeder, November-December (eggs)	1



169°35′E
169°40′
11°10′N
11°10′
Waatwerik
Lojrong
Taka
Bwokwen
Eluk
11°05′
11°05′
TAKA
0
1
2
3
STATUTE MILES
169°35′
169°40′

TAKA ATOLL

Location: 11°21' N x 169°38' E.

Shape and Size: Triangle-shaped; Length - 9 miles (north to south); Width - 9 miles (east to west); Total lagoon area - 51.71 square miles; Total dry land - 0.21 square miles; Number of islands - 6; Height 15± feet.

Soil: Beach (ocean side) - coral rock, some sand; Beach (lagoon side) - mostly sand, some rocky areas; Interior soil - black peat over sand; Bwokwen Island - sand and rock only (see Fosberg, 1954, 1955, and 1956).

Vegetation: Twenty-three species; Taka (largest island) - 1/3 coconut trees, 2/3 scrubby forest, Eluk, Lojrong, and Waatwerik Islands - scrubby forest; Bwokwen Island - no vegetation (Fosberg, 1955, 1956).

Climate: Moderately dry, 60-70 inches of rainfall yearly; Mean air temperature-82° F; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - not inhabited; Present - not inhabited; due to closeness of Utirik (6 miles) humans periodically visit the atoll to harvest copra (Taka Island only), to fish, and to gather birds and their eggs 3 times a year (Utirik native, personal communication, October 1964).

Scientific Visits: Northern Marshall Islands Expedition - 5-9 December 1951; POBSP- 19-23 October 1964, 6 May 1967.

Avifauna: Nineteen bird species are presently known from Taka Atoll. These include 12 seabirds, 6 shorebirds, and 1 heron. Nine of these species are known breeders, three others are possible breeders, five are migrants, and two are classed as vagrants.

Taka Atoll is the only known locale in the Marshall and Gilbert Islands of the migrant *Erolia melanotus*, and the accidentals *Actitis macularia* and *Stercorarius* sp.

Nineteen species are listed in the following checklist which was derived from several sources: (1) POBSP, (a) 1964, (b) 1967); and (2) Fosberg, (a) 1955, (b) 1966. The sources are referred to in the checklist by corresponding numbers and letters. The thirteen species marked by a single asterisk are new species records for Taka Atoll; the five species marked by double asterisks are new atoll breeding records.

Taka Atoll Avifauna Checklist

	Species	Status	Source
1)	<u>Puffinus pacificus</u>*	Resident breeder**	lab
2)	<u>Phaethon rubricauda</u>*	Resident breeder**	lab
3)	<u>Sula sula</u>*	Resident breeder**	lab
4)	<u>Sula leucogaster</u>*	Resident breeder?	lab
5)	<u>Fregata minor</u>*	Resident breeder?	lab
6)	<u>Egretta sacra</u>*	Resident breeder?	lab
7)	<u>Pluvialis dominica</u>	Migrant	lab
8)	<u>Numenius tahitiensis</u>	Migrant	lab, 2b
9)	<u>Actitis macularia</u>*	Vagrant	la
10)	<u>Heteroscelus incanum</u>*	Migrant	lab
11)	<u>Arenaria interpres</u>	Migrant	lab, 2b
12)	<u>Erolia melanotos</u>*	Migrant	la
13)	<u>Stercorarius</u> sp.*	Vagrant	la
14)	<u>Sterna sumatrana</u>*	Resident breeder **	lab
15)	<u>Sterna fuscata</u>	Resident breeder	lab, 2ab
16)	<u>Thalasseus bergii</u>*	Resident breeder**	lab
17)	<u>Anous stolidus</u>	Resident breeder	lab, 2ab
18)	<u>Anous tenuirostris</u>	Resident breeder	lab, 2ab
19)	<u>Gygis alba</u>	Resident breeder	lab, 2b

POBSP personnel have collected 61 specimens of 15 species (Table 4). Ten of these 15 species are specimen records of species not previously known from Taka Atoll; the other 5 represent the first specimen confirmation of species known previously only from sight records. No other specimens are known from Taka Atoll.

Species Accounts

1) <u>Puffinus pacificus</u> Wedge-tailed Shearwater

Habitat -- October 1964 - nest burrows located in grassy (<u>Lepturus</u>) area on southeast side of Lojrong, burrows 2-3 feet deep in sandy soil; May 1967 - burrows on Lojrong, same location as in 1964.

Numbers -- October 1964 - Lojrong 5 large young (area not observed at night so adult population status unknown, however, one chick regurgitated squid indicating adults were still feeding it - estimated adult population 10-12); May 1967 - Lojrong none observed during day, presence of active burrows suggests at least 24 adults are present nocturnally.

Status -- Resident breeder. October 1964 - 5 young almost fledged, another burrow was empty suggesting that a 6th chick had already fledged; May 1967 - 12 active burrows found, no eggs or young present. This is a new breeding record for Taka Atoll.

TABLE 4. Bird specimens collected by POBSP from Taka Atoll

Species	Museum		Sex	Age	Location	Date	Status	Collector
Puffinus pacificus	USNM	494820	?	N	Lojrong	10-23-64	Skin	Amerson
Sula sula	"	498367	?	?	Taka I.	10-20-64	Skull	"
Sula leucogaster	"	543356	♂	A	Eluk	5-6-67	Skin	"
Fregata minor	"	498368	?	?	Taka I.	10-20-64	Skull	"
Pluvialis dominica	"	494745	♀	-	"	"	Skin	Huber
Arenaria interpres	"	494759	?	-	"	"	"	Clapp
" "	"	494760	?	-	"	"	"	"
Actitis macularia	"	495038	♂	-	"	10-22-64	"	Wislocki
Heteroscelus incanum	"	494895	♂	-	"	"	"	Clapp
" "	"	543402	♂	A	Eluk	5-6-67	"	Amerson
Erolia melanotos	"	494814	♂	-	Lojrong	10-20-64	"	Huber
Sterna sumatrana	"	494588	♂	-	Bwokwen	10-22-64	"	Lehner
" "	"	494589	♂	-	"	"	"	"
" "	"	494590	♂	-	"	"	"	"
" "	"	543220	♂	A	"	5-6-67	"	Amerson
Sterna fuscata	"	494707	♀	-	Taka I.	10-20-64	"	Amerman
" "	"	494708	♀	-	"	10-22-64	"	Huber
" "	"	494709	♂	-	"	"	"	"
" "	"	494710	♀	-	"	"	"	"
" "	"	494711	♀	-	"	"	"	"
" "	"	494712	♂	-	"	"	"	"
" "	"	494713	♂	-	"	"	"	"
" "	"	494714	♂	-	"	"	"	"
" "	"	494715	♀	-	"	"	"	"
" "	"	494716	♀	-	"	"	"	"
" "	"	496241	♂	-	"	"	"	"
" "	"	543396	♂	A	Lojrong	5-6-67	"	Amerson
" "	"	543397	♂	A	"	"	"	"
" "	"	543398	♀	A	"	"	"	"
" "	"	543399	♂	A	"	"	"	"
" "	"	543400	♂	A	"	"	"	"
" "	"	543486	?	A	"	"	"	"
" "	"	543487	♀	A	"	"	"	"
Thalasseus bergii	"	543433	♀	A	"	"	"	"
" "	"	543434	♀	A	"	"	"	"
" "	"	543435	♂	A	"	"	"	"
Anous stolidus	"	494654	♀	-	Eluk	10-22-64	"	Lehner
" "	"	494655	♀	-	Taka I.	10-23-64	"	Huber
" "	"	502903	-	-	Eluk	10-22-64	Alc.	Lehner
" "	"	Lost	-	A	Lojrong	5-6-67	Skin	Amerson
Anous tenuirostris	"	494533	♂	-	Eluk	10-22-64	"	Lehner
" "	"	494534	♂	-	"	"	"	"
" "	"	494535	♂	-	"	"	"	"
" "	"	494536	♀	-	"	"	"	"
" "	"	494537	♂	-	"	"	"	"
" "	"	494538	-	-	"	"	"	"
" "	"	543446	♂	A	Eluk	5-6-67	"	Amerson
Gygis alba	"	494612	♀	-	Taka I.	10-20-64	"	Huber

TABLE 4. Bird specimens collected by POBSP from Taka Atoll (cont'd)

Species	Museum	Sex	Age	Location	Date	Status	Collector
Gygis alba	USNM 494613	♂	-	Taka I.	10-20-64	Skin	Huber
" "	" 494614	♂	-	"	"	"	"
" "	" 494615	♂	-	"	"	"	"
" "	" 494616	♂	-	"	"	"	"
" "	" 494617	♂	-	"	"	"	Wislocki
" "	" 494618	♂	-	"	"	"	"
" "	" 494619	♀	-	"	"	"	"
" "	" 494620	♂	-	"	"	"	Wislocki and Lehner
" "	" 494621	♀	-	"	"	"	"
" "	" 494622	♀	-	Bwokwen	10-22-64	"	Lehner
" "	" 543407	♂	A	Taka I	5-6-67	"	Amerson
" "	" 543224	♂	A	Bwokwen	"	"	"
" "	" 543223	♀	A	Eluk	"	"	"

Specimen Records -- Other - none; POBSP - one (Table 4). This is a new species and specimen record for the atoll.

2) Phaethon rubricauda Red-tailed Tropicbird

Habitat -- October 1964 - flying over Taka, Eluk, and Waatwerik; May 1967 - flying above and nesting under Scaevola and Messerschmidia at Eluk.

Numbers -- October 1964 Taka 5, Eluk 3, Lojron 0, Waatwerik 2; May 1967 - Eluk 25, Taka 0, Lojrong 0, Bwokwen 0.

Status -- Resident breeder. October 1964 - no nests found; however, three birds were observed in courtship flight above Eluk; May 1967 - nests containing eggs to fledglings present, also in flight courtship behavior. This is a new breeding record.

Specimen Records -- None. This observation represents a new species sight record for Taka Atoll.

3) Sula sula Red-footed Booby

Habitat -- October 1964 - skeletal parts found around old fire pit near old native huts on Taka, old nest in low Messerschmidia bush on Lojrong; May 1967 - subadults roosting in Messerschmidia and flying over Eluk, also flying over lagoon.

Numbers -- October 1964 - no live individuals observed, 8 skulls recovered, one kept, from fire pit on Taka, visiting natives apparently have driven this species from the atoll; May 1967 - Eluk 25 (some recently killed by natives), lagoon 4.

Status -- Resident breeder. October 1964 - one old nest which appeared to be a Red-footed Booby nest was found on Lojrong; May 1967 - no evidence of breeding. If the 1964 nest observation is valid, this is a new breeding record for the atoll.

Specimen Records -- Other - none; POBSP - one (Table 4). This represents a new species and specimen record from Taka Atoll.

4) Sula leucogaster Brown Booby

Habitat -- October 1964, flying over Taka and Eluk, skeletal parts found around old fire pit Taka, roosting on Bwokwen; May 1967 - flying above Eluk and the lagoon.

Numbers -- December 1951 - present (Fosberg, 1966); October 1964 - Taka 1, plus 7 skulls, Eluk 2, Bwoken 3, an immature Brown Booby was seen over the lagoon on 21 October (at dusk) bearing an orange plastic streamer on its left leg which indicated it was banded by POBSP personnel at Sand Island, Johnston Atoll; May 1967 - Eluk 2, lagoon 2.

Status -- Resident breeder? No evidence of breeding.

Specimen Records -- Other - none; POBSP - one (Table 4). This is a new specimen record for Taka Atoll.

5) Fregata minor — Great Frigatebird

Habitat -- October 1964 - skeletal parts found around old fire pit near old native huts on Taka; May 1967 - observed flying above Eluk and the lagoon.

Numbers -- October 1964 - no live individuals observed, one skull recovered from fire pit on Taka, visiting natives have apparently driven this species from the Atoll; May 1967 - Eluk 2, lagoon 12, other islands 0.

Status -- Resident breeder? No evidence of breeding.

Specimen Records -- Other - none; POBSP - one (Table 4). This constitutes a new species and specimen record from the atoll.

6) Egretta sacra — Reef Heron

Habitat -- October 1964 - seen on exposed reef and rocky beach of Taka and Waatwerik; May 1967 - on rocky seaward beach of Taka.

Numbers -- October 1964 - Taka 1, Waatwerik 2, May 1967 - Taka 1.

Status -- Resident breeder? No evidence of breeding.

Specimen Records -- None. This is a new species sight record for Taka Atoll.

7) Pluvialis dominica — Golden Plover

Habitat -- October 1964 - seen on sandy and rocky beach areas on all islands; May 1967 - rocky seaward beach of Taka.

Numbers -- October 1964 - Taka 10-20, Eluk 5-10, Lojrong 5-10, Waatwerik 5, Bwokwen 6; May 1967 - Taka 1.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - one (Table 4). This is a new species and specimen record for the atoll.

8) Numenius tahitiensis — Bristle-thighed Curlew

Habitat -- 7 December 1951 - seen on Taka (Fosberg, 1966); October 1964- observed on rocky seaward beaches of Taka and Waatwerik; May 1967 - on rocky seaward beach of Taka.

Numbers -- 7 December 1951 - one seen on Taka (Fosberg, 1966); October 1964 - Taka 4, Waatwerik 2; May 1967 - Taka 1.

Status -- Migrant.

Specimen Records -- None.

9) Actitis macularia Spotted Sandpiper

Habitat -- October 1964 - on rocky seaward side of Taka Island, in association with flock of Ruddy Turnstones.

Numbers -- October 1964 - one seen on Taka Island.

Status -- Accidental.

Specimen Records -- Other - none; POBSP - one (Table 4). This is a new species and specimen record for all of Micronesia.

10) Heteroscelus incanum Wandering Tattler

Habitat -- October 1964 - seen on sandy lagoon (occasionally on seaward) beaches of Taka, Bwokwen, and Waatwerik; May 1967 - on rocky seaward beaches of Eluk, Taka, and Lojrong.

Numbers -- October 1964 - Taka 6, Bwokwen 1, Waatwerik 1; May 1967 - Eluk 1, Taka 1, Lojrong 1.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - two (Table 4). This represents a new bird species and specimen record for the atoll.

11) Arenaria interpres Ruddy Turnstone

Habitat -- 9 December 1951 - west end of Waatwerik (Fosberg, 1966); October 1964 - rocky and sandy beaches of Taka, Bwokwen, and Waatwerik; May 1967 - sandy and rocky beaches of Eluk, Taka, and Lojrong.

Numbers -- 9 December 1951 - small flock seen (Fosberg, 1966); October 1964 - Taka 150-200, Bwokwen 10, Waatwerik 5; May 1967 - Eluk 3, Taka 5, Lojrong 1.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - two (Table 4). These specimens represent a new specimen record from Taka Atoll.

12) Erolia melanotos Pectoral Sandpiper

Habitat -- 20 October 1964 - found in grassy (Lepturus) area on southeastern side of Lojrong.

Numbers -- 20 October 1964 - one found with a broken leg (caught alive but starving, soon died) on Lojrong.

Status - Migrant.

Specimen Records -- Other - none; POBSP - one (Table 4). This is a new species and specimen record for the Marshall Islands.

13) Stercorarius sp. Jaeger species

Habitat -- 21 October 1964 - observed flying over ship anchored in lagoon.

Numbers -- 21 October 1964 - one seen.

Status -- Accidental.

Specimen Records -- None. This observation represents a new species sight record for all of Micronesia.

14) Sterna sumatrana Black-naped Tern

Habitat -- October 1964 - sandy and rocky reef flat areas of Taka, Eluk, Lojrong, and Bwokwen; nesting on sandy area of Bwokwen; May 1967 - roosting and flying above sandy areas of Bwokwen and Eluk and the lagoon.

Numbers -- October 1964 - Taka 12, Lojrong 5-10, Eluk 5-10, Bwokwen 5-10; May 1967 - Bwokwen 12, Eluk 1, lagoon 5.

Status -- Resident breeder. October 1964 - one nest (with one egg) on bare sand of Bwokwen; May 1967 - no evidence of breeding on islands visited. The 1964 data constitute a new breeding record.

Specimen Records - Other - none; POBSP - three (Table 4). This collection constitutes a new species and specimen record for the atoll.

15) Sterna fuscata Sooty Tern

Habitat -- December 1951 - flying around Taka Island, nesting on the seaward side of Eluk, between the first two rows of Tournefortia bushes on absolutely bare gravel and sand (Fosberg, 1955, 1956); October 1964 - flying over all islands, actively nesting at southeast seaward corner of Taka Island on bare sand and gravel between low scrub plants; old nesting site (with broken egg shells) at southeast corner of Lojrong in grassy (Lepturus) area; May 1967 - few flying over Bwokwen, small colony on rocky-grassy area located on the lagoon side of Eluk (pile of freshly killed adults and young on lagoon beach), few flying over 1964 colony site at Taka, large colony over entire south and west portions of Lojrong.

Numbers -- December 1951 - few flying over Taka Island, thousands on Eluk (Fosberg, 1955, 1966); October 1964 - Lojrong skeletons and old egg shells, Eluk 1,000+ flying over, Taka 50-60,000 in nesting colony; May 1967 - Bwokwen few flying, Eluk 3,000 adults and 1,000 nestlings, Taka 25 flying, Lojrong 50,000 adults and 20,000 nestlings, lagoon few.

Status -- Resident breeder. December 1951 - Eluk hard to avoid stepping on the numerous scattered eggs (Fosberg, 1955, 1966); October 1964 - 8-10,000 nests with eggs or 1-2 week old chicks. (Note: The eggs were scattered and not close together as in most Sooty Tern colonies, suggesting that eggs had been collected for food by the Utirik natives. This was verified by Andy Moor, a Utirik Atoll inhabitant who, along with three others, visited Taka Atoll on 20-23 October and told us that eggs had been gathered about a month earlier. The four ate some Sooty Terns, their eggs and young, during their three-day stay on the atoll.) May 1967 - half-grown young to fledglings present.

Specimen Records -- Other - none; POBSP - 18 (Table 4). These Sooty Tern specimens represent the first specimen records for this species from Taka Atoll.

16) Thalasseus bergii Crested Tern

Habitat -- October 1964 - nesting on bare sand-gravel area in center of Sooty Tern colony at southeast section of Taka Island; observed flying over Bwokwen; May 1967 - flying over sandy and rocky areas of Bwokwen, Taka, and Lojrong; nests placed on the rocky southeast area of Lojrong.

Numbers -- October 1964 - Taka 30, Bwokwen 1; May 1967 - Bwokwen 2, Eluk 3, Taka 2, Lojrong 50± adults and one nestling, lagoon 4.

Status -- Resident breeder. October 1964 - 10 nests (with 1 egg each) seen on Taka; May 1967 - Lojrong one small nestling, possibly eggs present, but not found. This is a new breeding record.

Specimen Records -- Other - none; POBSP - three (Table 4). This represents a new species and specimen record for Taka Atoll.

17) Anous stolidus Brown Noddy

Habitat -- 8-9 December 1951 - "... Watwerok Islet [should be Eluk (Fosberg, pers. corres. 1966)] ... nesting on open pebble flats on the east end of the islet and in trees generally" (Fosberg, 1955, 1966); October 1964 - observed in forests and on sandy and rocky beaches on all islands except Lojrong, one skull found around cooking site near native hut on west side of Taka Island; May 1967 - flying over Bwokwen, roosting and nesting in Cocos and Pandanus at Eluk, Taka, and Lojrong.

Numbers -- 8-9 December 1951 - many seen on Eluk (Fosberg, 1966); October 1964 - Taka 50, Waatwerik 15, Eluk 100, Bwokwen 10; May 1967 - Bwokwen few, Eluk 500, Taka 50, Lojrong 200, lagoon 30.

Status -- Resident breeder. 8-9 December 1951 - nesting on Eluk (Fosberg, 1955, 1966); October 1964 - one nest with one egg found on Eluk; May 1967 - nests with eggs to fledglings.

Specimen Records -- Other - none; POBSP - four (Table 4). These represent the first specimens of this species to be collected from Taka Atoll.

18) _Anous tenuirostris_ Black Noddy

Habitat -- 7-8 December 1951 - nesting in trees on Eluk (Fosberg, 1966); October 1964 - present on all islands, nests of dead leaves in forked branches of _Messerschmidia_ bushes found on Eluk, Lojrong, and Waatwerik; May 1967 - flying over all islands and lagoon, roosting and nesting in _Messerschmidia_ at Eluk, Taka, and Lojrong.

Numbers -- 7-8 December 1951 - common Eluk (Fosberg, 1955, 1966); October 1964 - Taka 75-100, Eluk 500, Bwokwen 40, Lojrong 200, and Waatwerik 200; May 1967 - Bwokwen few, Eluk 500, Taka 50, Lojrong 200, lagoon 25.

Status -- Resident breeder. 7-8 December 1951 - nesting in trees on Eluk (Fosberg, 1955, 1966); October 1964 - nests with eggs or up to half-grown chicks on Eluk 200±, Lojrong, and Waatwerik; May 1967 - nests (with one egg) on Eluk, Taka, and Lojrong.

Specimen Records -- Other - none; POBSP - seven (Table 4). These represent the first _Anous tenuirostris_ specimens to be collected from Taka Atoll.

19) _Gygis alba_ White Tern

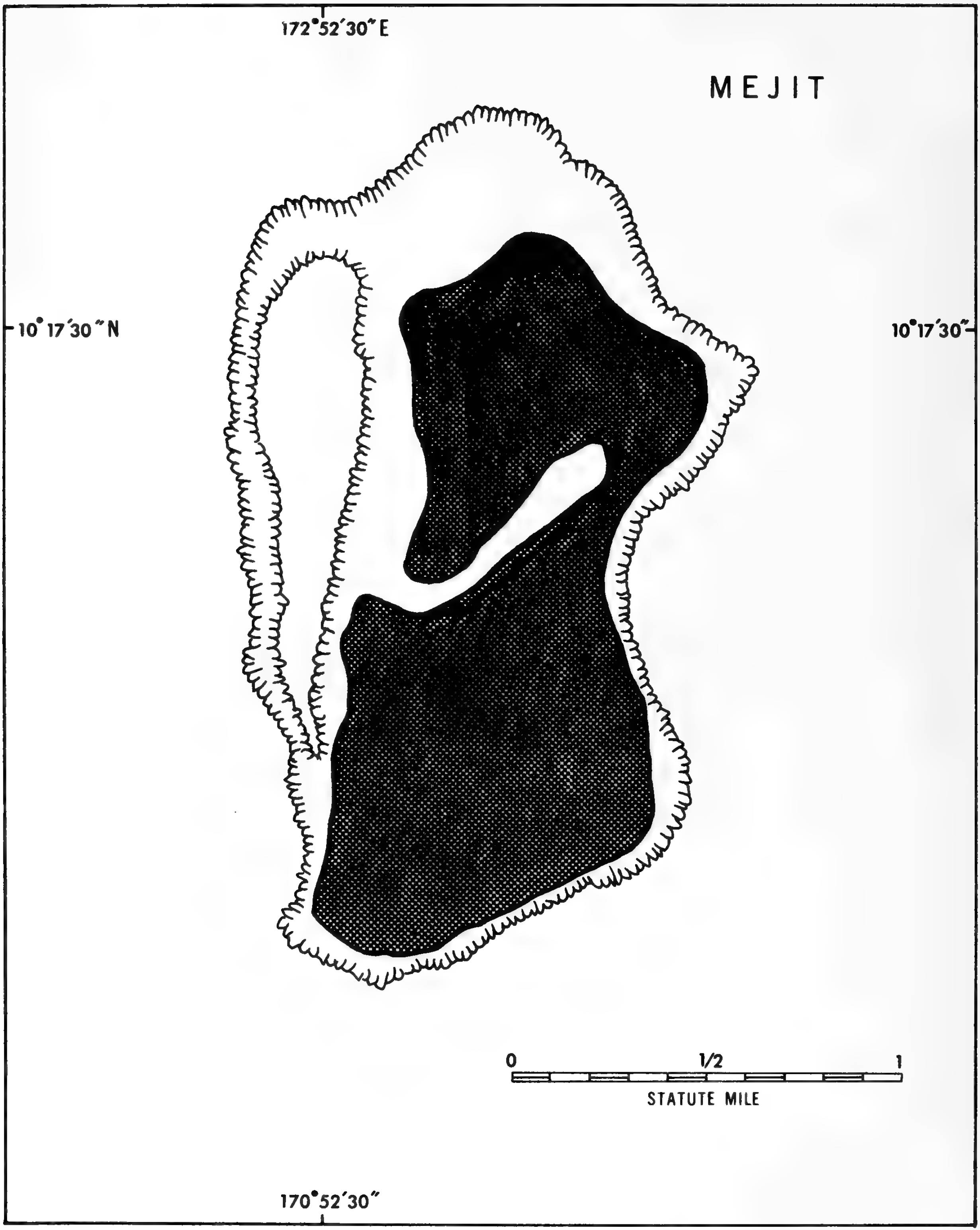
Habitat -- 7-8 December 1951 - nesting in bushes and trees (eggs laid on bare branches wherever a knothole or slight irregularity occurs) on Lojrongand Eluk (Fosberg, 1966); October 1964 - observed flying over and roosting in forests on all islands except Bwokwen, nesting in _Messerschmidia_ and _Pisonia_ on Lojrong and Waatwerik; May 1967 - flying above Bwokwen, as well as roosting in _Pisonia_ and tall _Messerschmidia_ at Eluk, Taka, and Lojrong.

Numbers -- 7-8 December 1951 - very abundant on Lojrong and Eluk (Fosberg, 1966); October 1964 - Taka 500, Eluk 200, Lojrong 200 Waatwerik 200; May 1967 - Bwokwen few, Eluk 500, Taka 50, Lojrong 200, lagoon 25.

Status -- Resident breeder. 7-8 December 1951 - nests with eggs or young in various stages on Lojrong and Eluk (Fosberg, 1966); October

1964 - few nests with eggs or up to half-grown young on Lojrong and Waatwerik; May 1967 - no nests observed, but collected specimens had bare brood patches.

Specimen Records -- Other - none; POBSP - 14 (Table 4). These White Tern specimens are the first to be collected from Taka Atoll.


172°52′30″ E
MEJIT
10° 17′30″ N
10°17′30″
0
1/2
1
STATUTE MILE
170°52′30″

MEJIT ISLAND

Location: 10°17' N x 170°54' E.

Shape and Size: Oval-shaped; Tip to tip (north-south) - 1.75 miles; Width - 0.75 miles; One land-locked salt lake with a marshy fringe present; Total dry land area - 1.32 square miles; Number of islands - 1; Height - 15-20 feet (Fosberg, 1956; Wiens, 1957; U.S. Navy, 1964).

Soil: Beach (leeward southwest side) - fine sand (Wiens, 1957).

Vegetation: Seventeen species; Vegetation, including trees, is low; Numerous *Cocos* and *Pandanus*, undergrowth not dense (Wiens, 1957).

Climate: Moderately wet, about 70 inches of rainfall yearly; Mean air temperature - 82° F.; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 50 in 1800's (Findlay, 1886); 299 in 1948 (Freeman, 1951); Present - inhabited, 329 in 1964 (U.S. Department of State, 1965).

Scientific Visits: Japanese visit (H. Orii) September 1931; Pacific Science Board (H. J. Wiens) - summer 1956.

Avifauna: Five bird species are known from Mejit Island. These 5 include 2 seabirds, 2 shorebirds, and 1 domestic fowl. Two of these 5 species are possible breeders.

Mejit Island possesses the only known record for *Diomedea immutabilis* in the Marshall Islands.

The following checklist presents the known bird species from Mejit Island, as well as their status and record source. The sources include: (1) POBSP band recovery; (2) Baker, 1951; (3) Hand-list of Japanese Birds (a) 1932, (b) 1942, (c) 1958; (4) Yale Cross-Cultural Survey, 1943; (5) YIZM collection. These sources are referred to in the checklist by the corresponding numbers and letters. The two species marked with an asterisk are new records for the island, and are based on POBSP band return records.

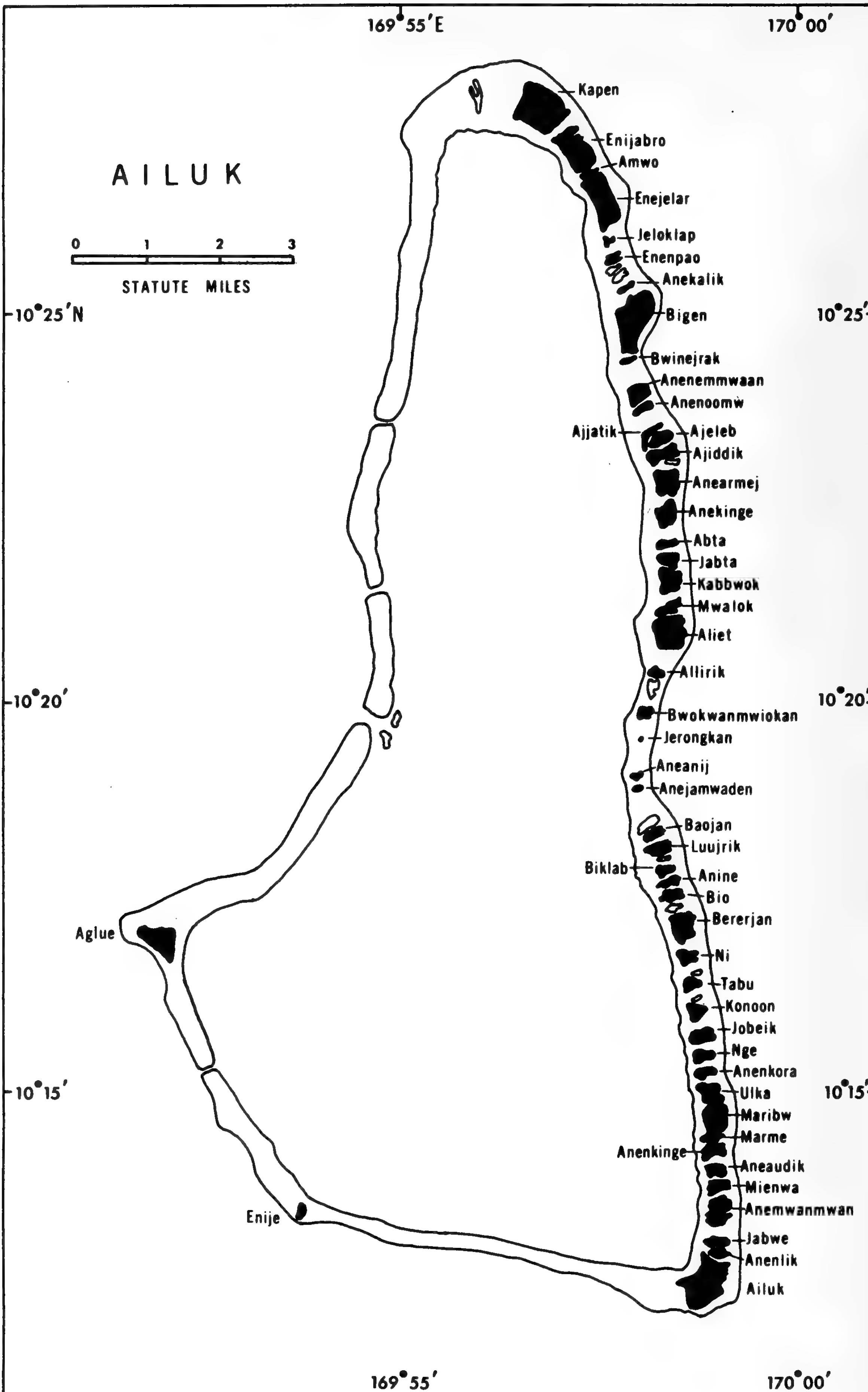
Mejit Island Aviafauna Checklist

Species	Status	Source
1) *Diomedea immutabilis**	Accidental	1
2) *Gallus gallus*	Introduced breeder?	4
3) *Heteroscelus incanum*	Migrant	5
4) *Arenaria interpres**	Migrant	1
5) *Gygis alba*	Resident breeder ?	2, 3abc

Bird specimens collected from Mejit Island include four specimens of two species. These birds are deposited in the Yamashina Institute of Zoology and Ornithology Museum in Tokyo,Japan.

TABLE 5. Bird specimens collected from Mejit Island

Species	Museum	Sex	Age	Location	Date	Status	Collector
Heteroscelus incanum	YIZM	♂	I	Mejit I.	09-19-31	Lost	H. Orii
" "	YIZM	♂	A	"	"	Skin	"
" "	YIZM	♂	A	"	"	Lost	"
Gygis alba	YIZM	♂	A	"	"	Skin	"


AILUK
0 1 2 3
STATUTE MILES
169°55′E
170°00′
10°25′N
10°25′
10°20′
10°20′
10°15′
10°15′
169°55′
170°00′
Kapen
Enijabro
Amwo
Enejelar
Jeloklap
Enenpao
Anekalik
Bigen
Bwinejrak
Anenemmwaan
Anenoomw
Ajjatik
Ajeleb
Ajiddik
Anearmej
Anekinge
Abta
Jabta
Kabbwok
Mwalok
Aliet
Allirik
Bwokwanmwiokan
Jerongkan
Aneanij
Anejamwaden
Baojan
Luujrik
Biklab
Anine
Bio
Bererjan
Ni
Tabu
Konoon
Jobeik
Nge
Anenkora
Ulka
Maribw
Marme
Anenkinge
Aneaudik
Mienwa
Anemwanmwan
Jabwe
Anenlik
Ailuk
Aglue
Enije

AILUK ATOLL

Location: 10°20' N x 169°56' E.

Shape and Size: Elongated triangle-shaped; Tip to tip (north-south) - 20 miles; Widest point (east-west, near southern base) - 5 to 8 miles; Total lagoon area - 89.62 square miles; Total dry land area - 2.19 square miles; Number of islands - 57; Height - up to 20 feet (Fosberg, 1956; U.S. Navy, 1964).

Soil: Beach (ocean side) - blackened coral rock; Beach (lagoon side) - mostly sandy; Inland - sandy (Fosberg, 1956).

Vegetation: Fifty-five species; Ailuk Island planted with *Cocos* and *Artocarpus*; Smaller islands mostly planted with *Cocos*, but broad strips of natural vegetation left on seaward side as a windbreak (Fosberg, 1956).

Climate: Moderately wet, about 70 inches of rainfall yearly; Mean air temperature-82° F.; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past- inhabited, 120 in 1800's (Findlay, 1886); 319 in 1948 (Freeman, 1951); Present - inhabited, 410 in 1964 (U.S. Department of State, 1965).

Scientific Visits: Japanese visit (H. Orii) 17-18 September 1931; Northern Marshall Islands Expedition - 24-31 December 1951; Pacific Science Board (H. J. Wiens) - summer 1956.

Avifauna: Thirteen species of birds are known from Ailuk Atoll. Of these 13, 7 are seabirds, 4 are shorebirds, 1 is a heron, and 1 is a domestic fowl. One species is known to breed on Ailuk, while 8 other species are potential breeders. The 4 shorebirds are migrants.

A checklist of the birds known to occur on Ailuk Atoll follows. Sources for this list include: (1) Fosberg, 1966; (2) Baker, 1951; (3) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (4) Yale Cross-Cultural Survey, 1943; and (5) YIZM collection. The sources are referred to in the checklist by the corresponding numbers and letters.

Ailuk Atoll Avifauna Checklist

Species	Status	Source
1) *Fregata minor*	Resident breeder ?, few	1
2) *Egretta sacra*	Resident breeder ?	1, 2, 3b, 5
3) *Gallus gallus*	Introduced breeder ?	1, 4
4) *Pluvialis dominica*	Migrant	1
5) *Numenius tahitiensis*	Migrant	1, 2, 3b, 5

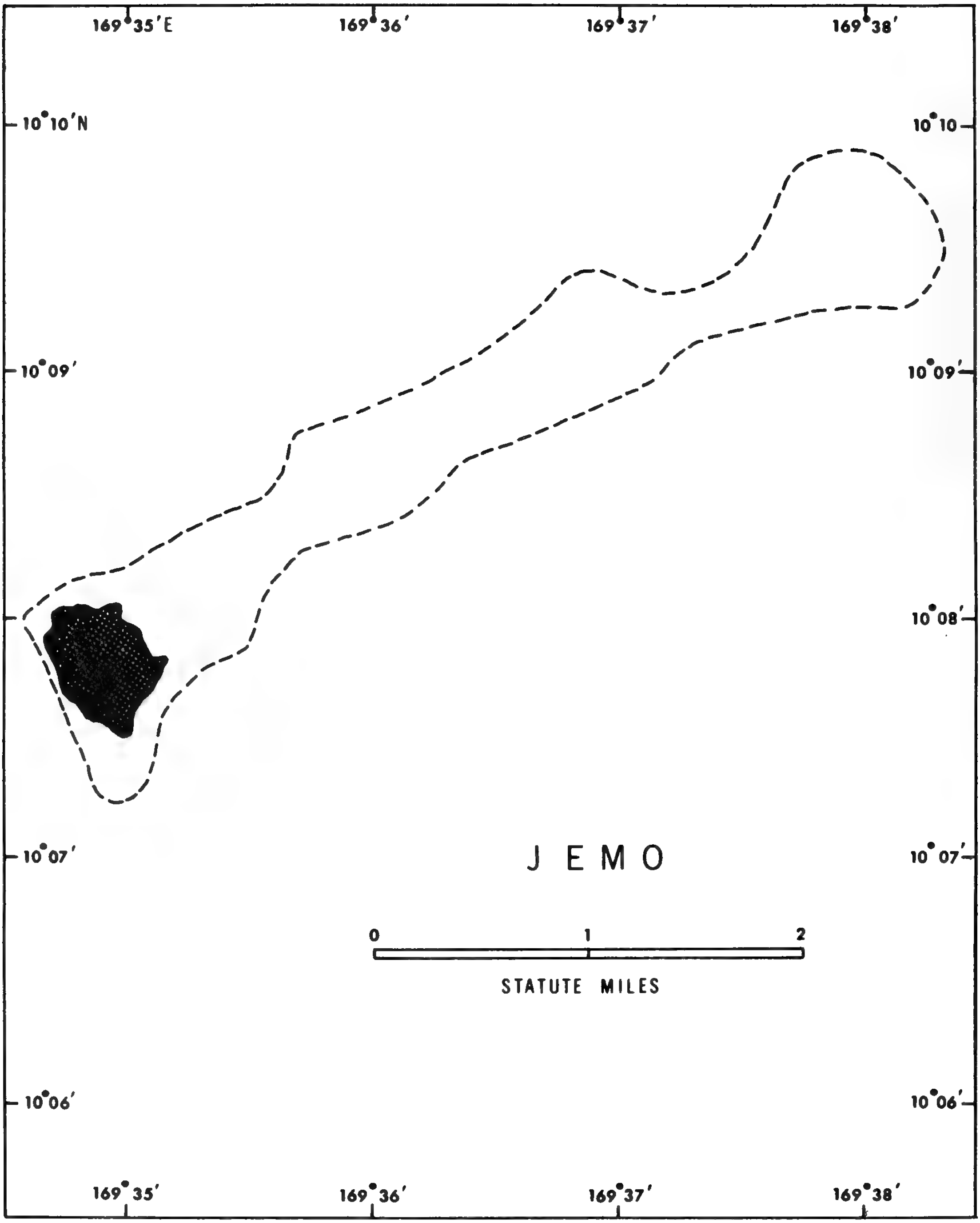
Species	Status	Source
6) Heteroscelus incanum	Migrant	2, 3b, 5
7) Arenaria interpres	Migrant	1
8) Sterna sumatrana	Resident breeder ?; 10	1
9) Sterna fuscata	Resident breeder ?; 1	1
10) Thalasseus bergii	Resident breeder ?; ?	2, 3ab, 5
11) Anous stolidus	Resident breeder ?; few	1
12) Anous tenuirostris	Resident breeder ?; 100+	1, 2, 3ab, 5
13) Gygis abla	Resident breeder, December; few	1

Four additional species, Puffinus pacificus, Puffinus nativitatus, Pterodroma hypoleuca, and Phaethon rubricauda, have been listed from Ailuk Atoll by various authors, including Fisher (1946) and Baker (1951). This was because of confusion as to the exact location of "Krusenstern Island" which Salvin (1888) listed as the type locality for Puffinus cuneatus and Oestrelata hypoleuca. I agree with Murphy (1951) and Ely and Amerson (in prep.), who suggest that the "Krusenstern" listed by Salvin is not Ailuk but one of the islands of the Leeward Hawaiian Chain.

Bird specimens collected from Ailuk Atoll include 13 specimens of 5 species which are located in the Yamashina Institute of Zoology and Ornithology Museum in Tokyo, Japan.

TABLE 6. Bird specimens collected at Ailuk Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Egretta sacra	YIZM	♀	A	Ailuk I.	09-17-31	Skin	H. Orii
" "	YIZM	♀	-	"	"	Lost	"
Numenius tahitiensis	YIZM	♂	A	"	"	Skin	"
"	YIZM	♂	A	"	"	"	"
"	YIZM	♂	A	"	"	"	"
"	YIZM	♀	-	"	"	"	"
Heteroscelus incanum	YIZM	♂	A	"	"	"	"
"	YIZM	♀	A	"	"	Lost	"
Thalasseus bergii	YIZM	♂	A	"	"	Skin	"
" "	YIZM	♂	A	"	09-18-31	"	"
Anous tenuirostris	YIZM	♂	A	"	09-17-31	"	"
" "	YIZM	♂	A	"	"	"	"
" "	YIZM	♂	A	"	09-18-31	"	"


169°35′E
169°36′
169°37′
169°38′
10°10′N
10°10
10°09′
10°09′
10°08′
10°08′
10°07′
10°07′
10°06′
10°06′
JEMO
0
1
2
STATUTE MILES
169°35′
169°36′
169°37′
169°38′

JEMO ISLAND

Location: 10°07' N x 169°33' E.

Shape and Size: Oval-shaped island about half a mile long (from northwest to southeast) situated at the southwest corner of a submerged reef (about 4.75 miles long) running from northeast to southwest; Total land area-0.07 square miles; Total area covered by land and reef 1.46 square miles (Fosberg, 1956); Height - 30 feet.

Soil: Beaches - sandy and rocky portions, some cobblestone sections; Inland - sandy and rocky portions, surface under Pisonia trees covered by a thick layer of a peat-like material, over a layer of cemented sand (Fosberg, 1954, 1955, 1966).

Vegetation: Total species 34; Strip of tall Pisonia forest on west portion, coconut plantation on eastern half and most of west half, undergrowth is very dense in places (Fosberg, 1966).

Climate: Moderately wet, 70-80 inches of rainfall annually; Mean annual temperature-82° F.; Wind prevalent from northeast (Fosberg, 1956).

Human Population: Past - uninhabited, bird and turtle sanctuary (pre-European times) visited once yearly to harvest limited number of animals and their eggs; cleared and planted to coconuts by Likiep inhabitants around 1900; uninhabited in 1951 although a frame house was present for use during copra harvesting; Present - uninhabited in 1964 and 1967, old frame house and associated copra shed deteriorating.

Scientific Visits: Northern Marshall Islands Expedition, 18-22 December 1951; POBSP - 23-24 October 1964 and 5 May 1967.

Avifauna: Fourteen bird species are known from Jemo Island. These include 8 seabirds, 4 shorebirds, 1 heron, and 1 introduced domestic fowl. Five of these species are known breeders, 5 others are possible breeders, and 4 are migrants.

Fourteen species are listed in the following checklist, which was derived from various sources: (1) POBSP, (a) 1964, (b) 1967; and (2) Fosberg, 1966. These sources are referred to in the checklist by corresponding numbers and letters. The six species marked by a single asterisk are new species records for Jemo Island; the four species marked by double asterisks are new island breeding records.

Jemo Island Avifauna Checklist

Species	Status	Source
1) Phaethon lepturus*	Resident breeder ?	lb
2) Sula sula	Resident breeder	lab, 2
3) Sula leucogaster	Resident breeder**	
4) Fregata minor	Resident breeder ?	lab, 2
5) Egretta sacra*	Resident breeder ?	lab
6) Gallus gallus	Introduced breeder ? now absent	2
7) Pluvialis dominica	Migrant	lab, 2
8) Numenius tahitiensis*	Migrant	lab
9) Heteroscelus incanum*	Migrant	lab
10) Arenaria interpres*	Migrant	lab
11) Sterna fuscata *	Resident breeder ?	lb
12) Anous stolidus	Resident breeder**	lab, 2
13) Anous tenuirostris	Resident breeder**	lab, 2
14) Gygis alba	Resident breeder**	lab 2

POBSP personnel have collected 30 specimens of 9 species (Table 7). Of these 9 species, 4 are specimen records of species not previously known from Jemo Island; the other 5 represent the first specimen confirmation of species previously known only from sight records. No other specimens are known from Jemo Island.

Species Accounts

1) Phaethon lepturus — White-tailed Tropicbird

Habitat -- May 1967 - flying about the island, just above the trees.

Numbers -- May 1967 - 3.

Status -- Resident breeder? May 1967 - in-flight courtship behavior observed, possibly nesting in holes of the high Pisonia trees.

Specimen Records --Other-none; POBSP-one(Table 7). This collection represents a new species and specimen record from Jemo Island.

2) Sula sula — Red-footed Booby

Habitat -- December 1951 - nesting in Pisonia trees (Fosberg, 1966); October 1964 - roosting and nesting in very high (75'-100') Pisonia trees; May 1967 - roosting and nesting in high Pisonia, some roosting in large Messerschmidia.

Numbers -- December 1951 - nesting in numbers (Fosberg, 1966); October 1964 - estimated population 1,000; May 1967 - 2,000.

TABLE 7. Bird specimens collected by POBSP from Jemo Island.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Phaethon lepturus	USNM 543050	♂	A	Jemo	5-5-67	Skin	Amerson
Sula sula	" 543060	♀	N	"	"	"	"
" "	" 543350	♂	A	"	"	"	"
" "	" 543351	♂	A	"	"	"	"
" "	" 543352	♂	A	"	"	"	"
" "	" 543052	♀	A	"	"	"	"
" "	" 543051	♀	A	"	"	"	"
Fregata minor	" 543380	♀	SA	"	"	"	"
Egretta sacra	" 494854	♀	-	"	10-24-64	"	Huber
Heteroscelus incanum	" 543401	♀	A	"	5-5-67	"	Amerson
Arenaria interpres	" 543438	♂	A	"	"	"	"
" "	" 543439	♂	A	"	"	"	"
Anous stolidus	" 543416	♀	A	"	"	"	"
" "	" 543476	♂	A	"	"	Wing/Skull	"
" "	" 543477	♂	A	"	"	Skin	"
" "	" 543475	♂	SA	"	"	"	"
Anous tenuirostris	" 543496	♂	A?	"	"	"	"
" "	" 543443	♂	A	"	"	"	"
" "	" 543444	?	SA	"	"	Wing/Skull	"
" "	" 543445	♂	SA	"	"	Skin	"
" "	" 543408	♀	A	"	"	"	"
Gygis alba	" 494623	♂	-	"	10-24-64	"	Huber
" "	" 494624	-	-	"	"	"	Wislocki
" "	" 494624	♂	-	"	"	"	Huber
" "	" 494626	♂	-	"	"	"	"
" "	" 494627	♀	-	"	"	"	"
" "	" 543221	?	A	"	5-5-67	"	Amerson
" "	" 543449	♀	A	"	"	"	"
" "	" 543450	♂	A	"	"	"	"
" "	" 543222	?	A	"	"	"	"

Status -- Resident breeder. December 1951 - nesting in numbers (Fosberg, 1966); October 1964 - approximately 200 nests (too high to observe whether eggs or chicks were present, but adults were on the nests); May 1967 - many large downy nestlings present (nests too high to determine if eggs or small young were present).

Specimen Records -- Other - none; POBSP - six (Table 7). This is a new specimen record for the island.

3) Sula leucogaster Brown Booby

Habitat -- 20 December 1951 - seen flying (Fosberg, 1966); October 1964 - roosting at night in coconut trees on west side of island; May 1967 - roosting and nesting on the ground at the edge of the vegetated portion on the northeast (windward) side.

Numbers -- 20 December 1951 - one seen (Fosberg, 1966); October 1964 - three observed; May 1967 - four seen during day.

Status -- Resident breeder. October 1964 - not breeding; May 1967 - one large downy nestling present. This is a new breeding record for Jemo.

Specimen Records -- None.

4) Fregata minor Great Frigatebird

Habitat -- 18 December 1951 - seen flying (Fosberg, 1966); October 1964 - flying over island and roosting in tops of tall Pisonia trees; May 1967 - adults and first-year birds roosting in tops of Pisonia trees.

Numbers -- 18 December 1951 - at least 15 (Fosberg, 1966); October 1964 - 10-20 observed; May 1967 - 10 seen.

Status -- Resident breeder? None breeding; however, there is a possibility that this species nests on Jemo Island.

Specimen Records -- Other - none; POBSP - one (Table 7). This collection represents a new specimen record from Jemo.

5) Egretta sacra Reef Heron

Habitat -- October 1964 - on rocky beach on east side of island; May 1967 - on rocky and sandy beach.

Numbers -- October 1964 - one observed and collected; May 1967 - one present.

Status -- Resident breeder? No evidence of breeding although they may breed here.

Specimen Records - Other - none; POBSP - one (Table 7). This is a new species and specimen record for Jemo Island.

6) Gallus gallus — Domestic Chicken

Habitat -- December 1951 - present (Fosberg, 1966).

Numbers -- December 1951 - present (Fosberg, 1966).

Status -- Introduced breeder? It is possible that this species bred in the past at Jemo Island.

Specimen Records -- None.

7) Pluvialis dominica — Golden Plover

Habitat -- December 1951 - present (Fosberg, 1966); October 1964 - observed on sandy and rocky beaches; May 1967 - on sandy beach.

Numbers -- December 1951 - "... only 2 were seen, possibly 2 sightings of the same individual" (Fosberg, 1966); October 1964 - estimated population 50; May 1967 - 2 observed; number banded 4.

Status -- Migrant.

Specimen Records -- None.

8) Numenius tahitiensis — Bristle-thighed Curlew

Habitat -- October 1964 - observed along sandy beaches; May 1967 - present on sandy and rocky beach areas.

Numbers -- October 1964 - 2 observed; May 1967 - 2.

Status -- Migrant.

Specimen Records -- None. This observation represents a new bird species record for the island.

9) Heteroscelus incanum — Wandering Tattler

Habitat -- October 1964 - observed along rocky beach areas; May 1967 - on sandy beach.

Numbers -- October 1964 - 8; May 1967 - 3.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - 1 (Table 7). This is a new species and specimen record for Jemo Island.

10) <u>Arenaria interpres</u> Ruddy Turnstone

Habitat -- October 1964 - observed along sandy and rocky beaches; May 1967 - present on sand beach.

Numbers -- October 1964 - estimated population 60; May 1967 - 6.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - 2 (Table 7). These specimens constitute a new species and specimen record for Jemo Island.

11) <u>Sterna fuscata</u> Sooty Tern

Habitat -- May 1967 - observed flying over the island about noontime headed in a northerly direction.

Numbers -- May 1967 - 2.

Status -- Resident breeder? May 1967 - not breeding.

Specimen Records -- None. This observation represents a new species sight record from Jemo Island.

12) <u>Anous stolidus</u> Brown Noddy

Habitat -- December 1951 - present (Fosberg, 1966); October 1964 - roosting on sandy beaches and on upper branches of high <u>Pisonia</u> trees; May 1967 - flying about, roosting in tops of <u>Pisonia</u> and <u>Messerschmidia</u>, nests placed at bases of palm fronds.

Numbers -- December 1951 - quite common (Fosberg, 1966); October 1964 - 25-50 present; May 1967 - 1,000 estimated.

Status -- Resident breeder. December 1951-not seen nesting(Fosberg,1966); 23-24 October 1964 - no nests observed; 5 May 1967 - many nests with young observed. This consititutes a new breeding record for Jemo.

Specimen Records -- Other - none; POBSP - 4 (Table 7). This collection represents a new specimen record for the island.

13) <u>Anous tenuirostris</u> Black Noddy

Habitat -- December 1951 - present (Fosberg, 1966); October 1964 - roosting and nesting in tops of high <u>Pisonia</u> trees; May 1967 - flying about, roosting and nesting in tops of <u>Pisonia</u> and <u>Messerschmidia</u>.

Numbers -- December 1951 - several were seen (Fosberg, 1966); October 1964 - estimated population 150-250; May 1967 - 2,000 estimated.

Status -- Resident breeder. October 1964 - several nests were seen but due to excessive heights their contents could not be determined; May 1967 - many nests with young present. This is a new breeding record.

Specimen Records -- Other - none; POBSP - 5 (Table 7). This is a new specimen record for Jemo.

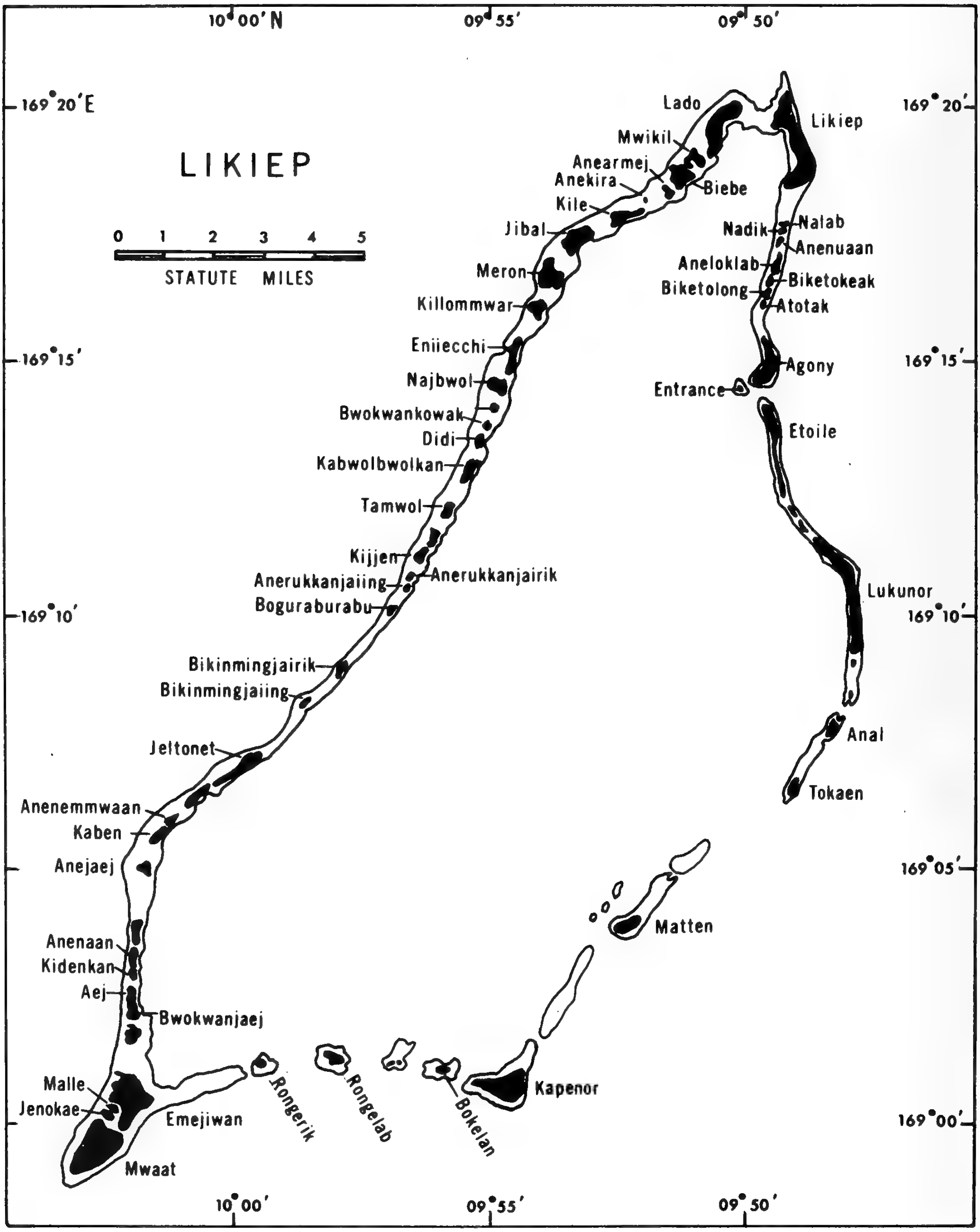
14) <u>Gygis alba</u> White Tern

Habitat -- 18-19 December 1951 - present (Fosberg, 1966); October 1964 - roosting and nesting on low to high vegetation (<u>Messerschmidia</u>, <u>Scaevola</u>, and <u>Pisonia</u>); May 1967 - flying about, roosting in same vegetation as in 1964.

Numbers -- 18-19 December 1951 - occasional (Fosberg, 1966); October 1964 - 500-750 estimated; May 1967 - 500 estimated.

Status -- Resident breeder. 18-19 December 1951 - not seen nesting (Fosberg, 1966); October 1964 - several nests (each with an egg) were seen; May 1967 - no nests observed, but specimens collected had bare brood patches. This is a new breeding record.

Specimen Records -- Other - none; POBSP - 9 (Table 7). This collection represents a new specimen record for the island.



LIKIEP
0 1 2 3 4 5
STATUTE MILES
10°00'N
09°55'
09°50'
169°20'E
169°15'
169°10'
169°05'
169°00'
169°20'
169°15'
169°10'
10°00'
09°55'
09°50'
Lado
Likiep
Mwikil
Anearmej
Anekira
Biebe
Kile
Jibal
Nadik
Nalab
Anenuaan
Meron
Aneloklab
Biketokeak
Biketolong
Atotak
Killommwar
Eniiecchi
Agony
Entrance
Najbwol
Bwokwankowak
Etoile
Didi
Kabwolbwolkan
Tamwol
Kijjen
Anerukkanjaiing
Anerukkanjairik
Boguraburabu
Lukunor
Bikinmingjairik
Bikinmingjaiing
Anal
Jeltonet
Tokaen
Anenemmwaan
Kaben
Anejaej
Matten
Anenaan
Kidenkan
Aej
Bwokwanjaej
Malle
Jenokae
Rongerik
Rongelab
Bokelan
Kapenor
Emejiwan
Mwaat

LIKIEP ATOLL

Location: 09°53' N x 169°09'E.

Shape and Size: Irregular trapezoid-shaped; Tip to tip (northwest-southeast) - 20 miles; Widest point (northeast-southwest) - 11 miles; Total lagoon area - 180.08 square miles, Total dry land area - 3.63 square miles; Number of islands-112; Height - 6 feet (Fosberg, 1956; U.S. Navy, 1964).

Soil: No available data (see Fosberg, 1956).

Vegetation: Eighty-one species; Most larger islands planted with Cocos (Fosberg, 1955, 1956).

Climate: Moderately wet, about 70 inches of rainfall yearly; Mean air temperature-82° F.; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 300 in 1800's (Findlay, 1886); 568 in 1948 (Freeman, 1951); Present - inhabited, 546 in 1964 (U.S. Department of State, 1965).

Scientific Visits: Japanese visit (H. Orii) 16, 21 September 1931; Northern Marshall Islands Expedition - 11-18 December 1951; U.S. Navy (F. R. Fosberg) - 4-14 February 1956; Pacific Science Board (H. J. Wiens) - summer 1956.

Avifauna: Eleven bird species are known from Likiep Atoll. These include 5 seabirds, 3 shorebirds, 1 heron, 1 cuckoo, and 1 domestic fowl. Seven species are potential breeders, but none of these are known to breed. The 3 shorebirds and 1 cuckoo are migrants.

A checklist of the birds known to occur on Likiep Atoll follows. Source material for this list includes: (1) Fosberg, 1966; (2) Baker, 1951; (3) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (4) POBSP band data; (5) Yale Cross-Cultural Survey, 1943; and (6) YIZM collection. These sources are referred to in the checklist by corresponding numbers and letters. The one species marked with an asterisk is a new bird record for Likiep Atoll, and was the result of a POBSP banded bird being picked up on the atoll by a native and the band sent to Washington.

348-415 O-69—6

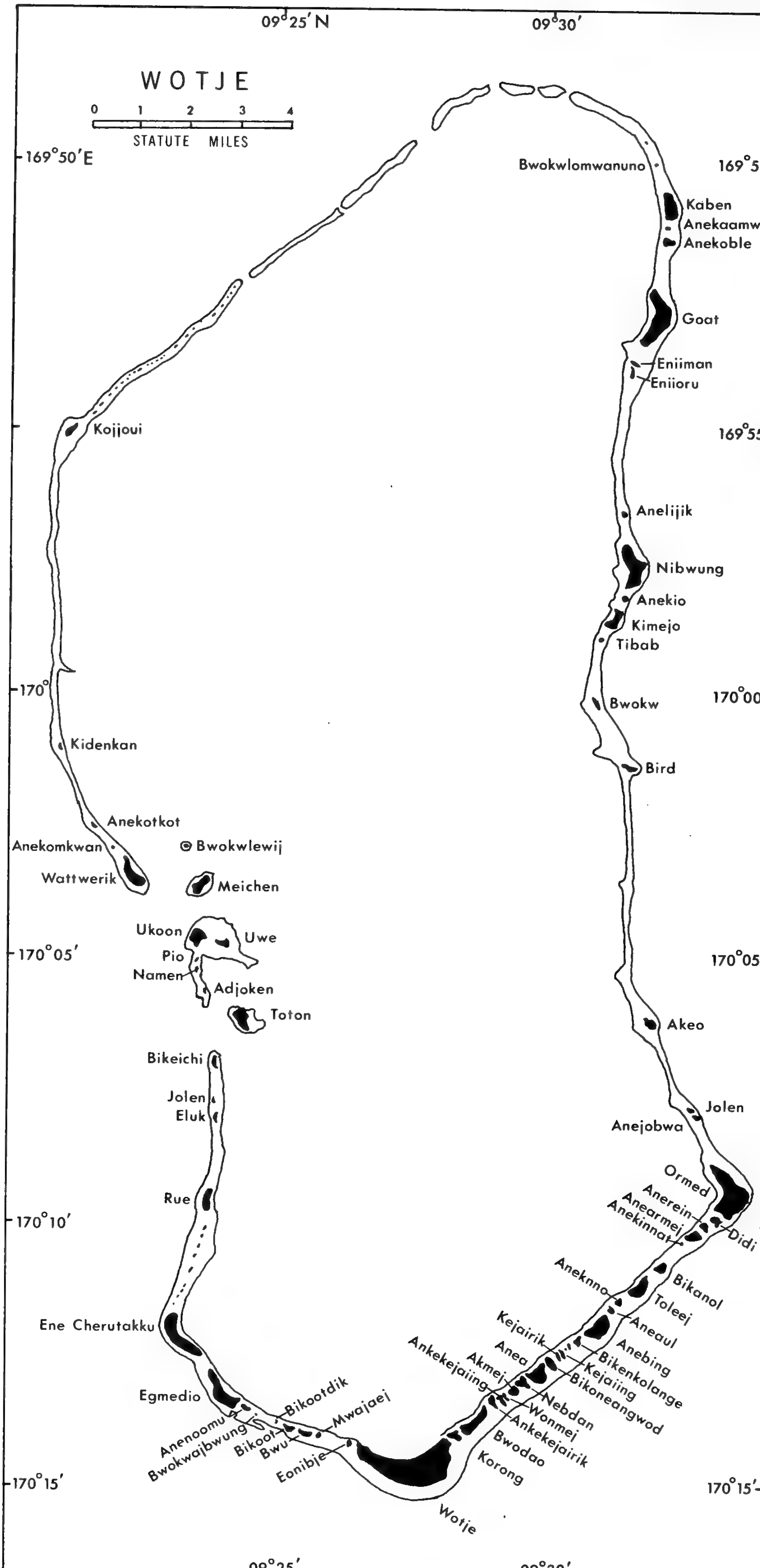
Likiep Atoll Avifauna Checklist

Species	Status	Source
1) *Sula sula*	Resident breeder ?	2, 3ab, 4, 6
2) *Sula leucogaster**	Resident breeder ?	4
3) *Fregata minor*	Resident breeder ?	2, 3ab, 6
4) *Egretta sacra*	Resident breeder ?	1, 2, 3b, 6
5) *Gallus gallus*	Introduced breeder ?	1, 5
6) *Pluvialis dominica*	Migrant	1, 2, 3ab, 6
7) *Heteroscelus incanum*	Migrant	2, 3b, 6
8) *Arenaria interpres*	Migrant	1, 2, 3ab, 6
9) *Anous stolidus*	Resident breeder ?; few	1
10) *Gygis alba*	Resident breeder ?; few	1, 2, 3ab, 6
11) *Urodynamis taitensis*	Migrant	1

Bird specimens collected from Likiep Atoll include 13 specimens of 7 species, all of which are in the Yamashina Institute of Zoology and Ornithology Museum, Tokyo, Japan.

TABLE 8. Bird specimens collected from Likiep Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Sula sula	YIZM	♂	Juv	Likiep I	09-21-31	Skin	H. Orii
Fregata minor	YIZM	♂	Juv	Rikieb (*sic*)	"	Lost	"
Egretta sacra	YIZM	♂	Juv	Likiep I	09-16-31	Skin	"
" "	YIZM	♀	A	"	"	Lost	"
" "	YIZM	♀	A	"	09-21-31	Skin	"
Pluvialis dominica	YIZM	♂	A	"	09-16-31	"	"
Heteroscelus incanum	YIZM	♂	A	"	"	Lost	"
" "	YIZM	♂	A	"	"	Skin	"
" "	YIZM	♂	A	"	09-21-31	"	"
" "	YIZM	♂	A	"	"	"	"
Arenaria interpres	YIZM	♂	A	"	09-16-31	Lost	"
" "	YIZM	♀	A	"	"	Skin	"
Gygis alba	YIZM	♂	A	Rikieb (sic)	"	"	"



WOTJE
0 1 2 3 4
STATUTE MILES
09°25′N
09°30′
169°50′E
169°50′
169°55′
170°
170°00′
170°05′
170°05′
170°10′
170°15′
170°15′
09°25′
09°30′
Bwokwlomwanuno
Kaben
Anekaamw
Anekoble
Goat
Eniiman
Eniioru
Kojjoui
Anelijik
Nibwung
Anekio
Kimejo
Tibab
Bwokw
Kidenkan
Bird
Anekotkot
Anekomkwan
Bwokwlewij
Wattwerik
Meichen
Ukoon
Uwe
Pio
Namen
Adjoken
Toton
Akeo
Bikeichi
Jolen
Eluk
Jolen
Anejobwa
Ormed
Anerein
Anearmej
Anekinnat
Didi
Rue
Aneknno
Bikanol
Toleej
Aneaul
Ene Cherutakku
Kejairik
Anebing
Anea
Bikenkolange
Kejaiing
Ankekejaiing
Akmej
Bikoneangwod
Nebdan
Wonmej
Egmedio
Ankekejairik
Bikootdik
Mwajaej
Anenoomu
Bwokwajbwung
Bikoot
Bwu
Eonibje
Bwodao
Korong
Wotje

WOTJE ATOLL

Location: 09°27' N x 170°02' E.

Shape and Size: Irregular rectangle-shaped; Tip to tip (east-west) - 26 miles; Width (north-south) - 6 to 12 miles; Total lagoon area - 298.63 square miles; Total dry land area - 3.34 square miles; Number of islands - 72; Height - 30 feet (Fosberg, 1956; U.S. Navy, 1964).

Soil: No available data.

Vegetation: Three known species; Some replanting of Cocos since World War II, but many islands grassy or with low scrub (Fosberg, 1956; U.S. Navy, 1964).

Climate: Moderately wet, about 70-80 inches of rainfall yearly; Mean air temperature-82° F.; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 300 in 1800's (Findlay, 1886); 328 in 1948 (Freeman, 1951); Present - inhabited, 498 in 1964 (U.S. Department of State, 1965).

Scientific Visits: Japanese expedition (H. Orii) - 15, 18, 22, 23 September 1931.

Avifauna: Twelve bird species occur on Wotje Atoll. Four of these are seabirds, 4 are shorebirds, while 1 each includes a heron, a cuckoo, a pigeon, and a domestic fowl. No birds are known to breed on Wotje Atoll; however, 7 species are potential breeders. The 4 shorebird species and the cuckoo are migrants.

A checklist of the bird species recorded on Wotje Atoll follows. Source material for this list includes: (1) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (2) Baker, 1951; (3) Yale Cross-Cultural Survey, 1943; (4) Mathews, 1933; (5) Peters, 1937; (6) Mayr, 1945; (7) Bogert, 1937; (8) YIZM collection; and (9) POBSP band return data. These sources are referred to in the checklist by the corresponding numbers and letters. The one species marked by a single asterisk is a new species record for Wotje Atoll.

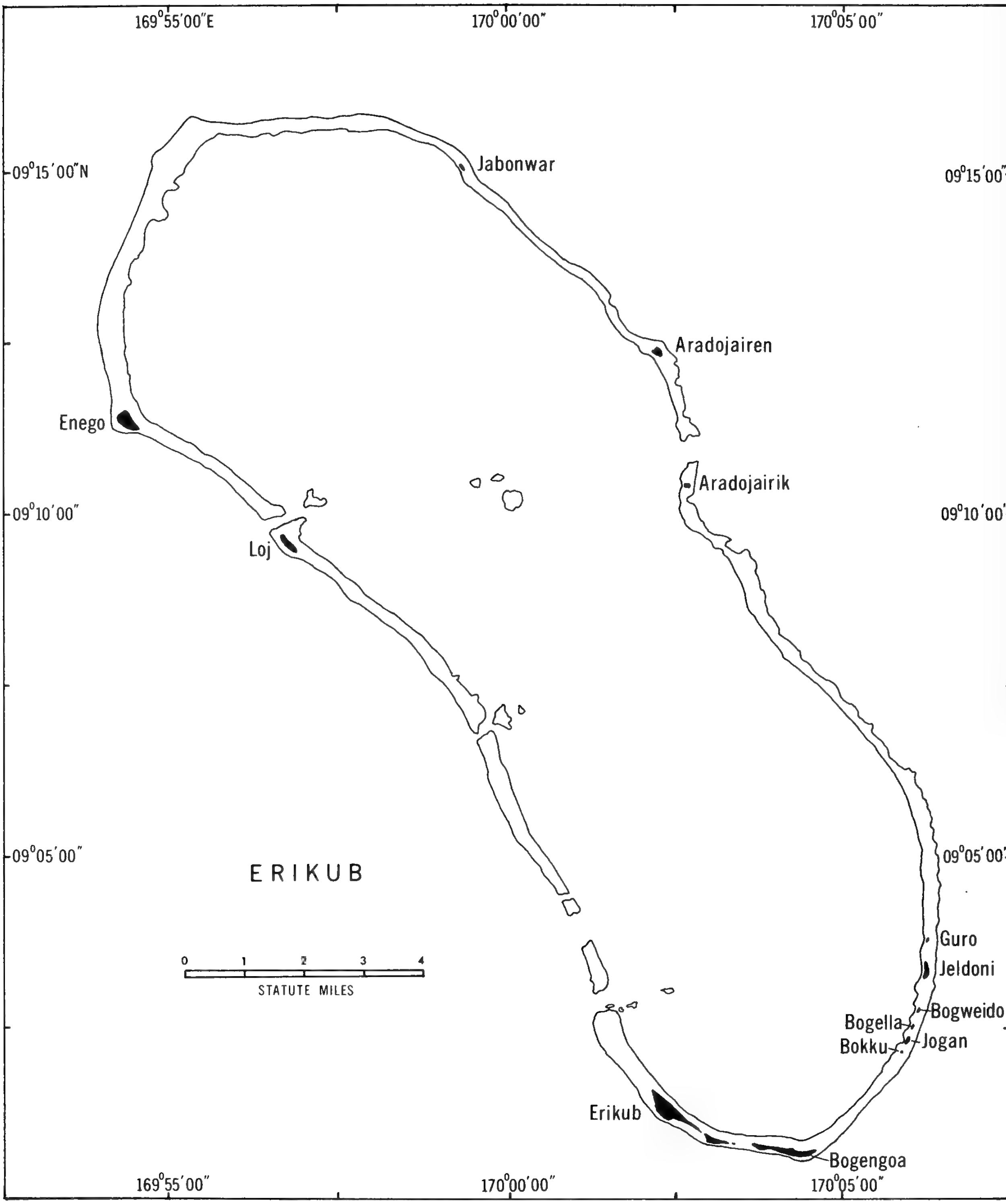
Wotje Atoll Avifauna Checklist

Species	Status	Source
1) *Fregata minor**	Resident breeder ?	9
2) *Egretta sacra*	Resident breeder ?	1b, 2, 8
3) *Gallus gallus*	Introduced breeder ?	3
4) *Numenius phaeopus*	Migrant	1ab, 2, 8
5) *Numenius tahitiensis*	Migrant	1ab, 2, 8
6) *Heteroscelus incanum*	Migrant	1b, 2, 8
7) *Arenaria interpres*	Migrant	1ab, 2, 8
8) *Anous stolidus*	Resident breeder ?	1ab, 2, 8
9) *Anous tenuirostris*	Resident breeder ?	1ab, 2, 8
10) *Gygis alba*	Resident breeder ?	1ab, 2, 8
11) *Ducula oceanica ratakensis*	Resident breeder ?	1ab, 2, 4, 5, 6, 8
12) *Urodynamis taitensis*	Migrant	1ab, 2, 7, 8

Bird specimens collected from Wotje Atoll include 32 specimens of 10 species, all of which are located in the Yamashina collection in Tokyo, Japan.

TABLE 9. Bird specimens collected from Wotje Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Egretta sacra	YIZM	♀	-	Wozzie(sic)	09-22-31	Skin	H. Orii
Numenius phaeopus	YIZM	♂	-	"	09-18-31	"	"
"	YIZM	♂	-	"	09-22-31	"	"
"	YIZM	♂	-	"	09-15-31	"	"
"	YIZM	♀	-	"	"	"	"
Numenius tahitiensis	YIZM	♂	-	"	"	"	"
"	YIZM	♂	-	"	"	"	"
"	YIZM	♂	-	"	"	"	"
"	YIZM	♂	A	"	"	"	"
"	YIZM	♀	-	"	"	"	"
"	YIZM	♀	-	"	"	"	"
"	YIZM	♀	-	"	"	"	"
"	YIZM	♀	-	"	"	"	"
Heteroscelus incanum	YIZM	♀	A	"	"	"	"
Arenaria interpres	YIZM	♂	I	"	"	"	"
Anous stolidus	YIZM	♂	A	"	09-22-31	-	-
"	YIZM	♂	A	"	"	-	-
"	YIZM	♂	A	"	"	-	-
Anous tenuirostris	YIZM	♂	A	"	09-15-31	Skin	H. Orii
"	YIZM	♂	A	"	"	"	"
"	YIZM	♂	A	"	"	"	"
Gygis alba	YIZM	♂	A	"	09-23-31	"	"
"	YIZM	♂	A	"	"	"	"
Ducula oceanica ratakensis	YIZM	♂	A	"	09-22-31	"	"
"	YIZM	♂	A	"	"	"	"
"	YIZM	♂	A	"	"	Lost	"
"	YIZM	♂	Juv	"	"	Skin	"
"	YIZM	♀	-	"	"	"	"
"	YIZM	♀	-	"	09-23-31	Lost	"
"	YIZM	♀	A	"	"	"	"
"	YIZM	♀	A	"	"	Skin	"
Urodynamis taitensis	YIZM	♂	A	"	"	Lost	"



169°55'00"E
170°00'00"
170°05'00"
09°15'00"N
09°15'00"
09°10'00"
09°10'00"
09°05'00"
09°05'00"
169°55'00"
170°00'00"
170°05'00"
Jabonwar
Aradojairen
Enego
Aradojairik
Loj
ERIKUB
0
1
2
3
4
STATUTE MILES
Guro
Jeldoni
Bogweido
Bogella
Bokku
Jogan
Erikub
Bogengoa

ERIKUB ATOLL

Location: 09°08' N x 170°02' E.

Shape and Size: Narrow oblong shaped (oriented in a northwest-southeast direction); Length - 17 miles; Width - 5 miles; Lagoon size - 116.34 square miles; Total land area - 0.35 square miles; Number of islands - 14 (Freeman, 1951); Height - 20± feet.

Soil: Beaches (ocean side) - mainly coral rock, some cobblestone, some sandy area; Beach (lagoon side) - mainly sandy, occasional coral rock outcrops; Inland - mostly sand mixed with rock, some humus areas.

Vegetation: Twenty-two species; Lagoon beach area - *Scaevola* and *Messerschmidia*; Seaward beach area - *Cocos* and *Pisonia*; Inland area - *Cocos*, *Pisonia*, *Pandanus* with thick undergrowth. Most of Erikub Island planted to coconut trees.

Climate: Moderately wet, 70-80 inches of rainfall annually; Mean annual temperature - 82° F.; Wind - prevalent from the northeast (Fosberg, 1956).

Human Population: Past - Some Wotje natives in semipermanent residence, not permanently inhabited, periodic visits by islanders for fishing and harvesting nuts from the planted coconut trees (Fosberg, 1956); Present - 1964, uninhabited but visited periodically for copra and fish, several well-kept unoccupied native huts on Erikub Island used during copra harvesting times, 1967, uninhabited, huts deteriorating.

Scientific Visits: POBSP - 24-28 October 1964, 4 May 1967.

Avifauna: Eighteen species of birds are presently known from Erikub Atoll. These include 11 seabirds, 5 shorebirds, 1 heron, and 1 duck. Six of these species are known breeders, 6 others are possible breeders, 5 are migrants, and 1 is an accidental.

Erikub Atoll is the only known locality in the Marshall and Gilbert Islands from which *Chen hyperborea* has been recorded.

Eighteen species are listed in the following checklist which was derived solely from POBSP data collected in 1964 (1a) and 1967 (1b). These sources are referred to in the checklist by corresponding numbers and letters. All 18 species are new species records for Erikub Atoll; these are marked by a single asterisk. The six species marked by double asterisks are new atoll breeding records.

Erikub Atoll Avifauna Checklist

Species	Status	Source
1) Phaethon rubricauda*	Resident breeder ?	la
2) Phaethon lepturus*	Resident breeder**	lab
3) Sula sula*	Resident breeder ?	la
4) Sula leucogaster*	Resident breeder**	lab
5) Fregata minor*	Resident breeder ?	lab
6) Fregata ariel*	Resident breeder ?	lb
7) Egretta sacra*	Resident breeder ?	lab
8) Chen hyperborea*	Accidental	la
9) Pluvialis dominica*	Migrant	lab
10) Numenius tahitiensis*	Migrant	lab
11) Heteroscelus incanum*	Migrant	lab
12) Arenaria interpres*	Migrant	lab
13) Crocethia alba*	Migrant	la
14) Sterna sumatrana*	Resident breeder**	lab
15) Thalasseus bergii*	Resident breeder ?	lab
16) Anous stolidus*	Resident breeder**	lab
17) Anous tenuirostris*	Resident breeder**	lab
18) Gygis alba*	Resident breeder**	lab

POBSP personnel have collected 62 specimens of 14 species (Table 10). All of these species are specimen records of species not previously known from Erikub Atoll. No other specimens are known from the atoll.

TABLE 10. Bird specimens collected by POBSP from Erikub Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Phaethon lepturus	USNM 494865	♀	-	Aradojairen	10-25-65	Skin	Huber
Sula leucogaster	" 494916	♀	-	Bogengoa	10-27-64	"	Lehner
" "	" 494917	♀	-	Aradojairik	"	"	Amerman
" "	" 494918	♀	-	"	"	"	"
" "	" 494919	♀	-	"	"	"	Huber
" "	" 494920	-	-	"	"	"	"
" "	" 494921	♂	-	"	"	"	Amerson
" "	" 494922	♂	-	"	"	"	"
" "	" 494923	♂	-	"	"	"	"
" "	" 494924	♂	-	"	"	"	"
" "	" 496247	♂	-	"	10-26-64	"	Clapp
Fregata minor	" 496246	♀	-	"	"	"	Huber
Egretta sacra	" 494855	♀	-	Enego	10-25-64	"	"
" "	" 494856	♂	-	Bogweido	10-26-64	"	"
" "	" 543458	♂	A	Bogengoa	5-4-67	"	Amerson
Chen hyperborea	" 494851	♂	-	Erikub	10-27-64	"	Huber

TABLE 10. Bird specimens collected by POBSP from Erikub (cont.)

Species	Museum	Sex	Age	Location	Date	Status	Collector
Pluvialis dominica	USNM 494746	♀	-	Loj	10-24-64	Skin	Huber
Numenius tahitiensis	" 494824	♂	-	"	"	"	"
Heteroscelus incanum	" 494896	♂	-	Aradojairen	10-25-64	"	"
" "	" 494897	♂	-	"	"	"	"
" "	" 543500	♀	A	Bogengoa	5-4-67	"	Amerson
" "	" 543501	♂	A	Erikub I	"	"	"
Arenaria interpres	" 494761	-	-	Loj	10-24-64	"	Huber
" "	" 494762	?	-	"	"	"	"
" "	" 543428	♀	A	Bogengoa	05-04-67	"	Amerson
Crocethia alba	" 494794	♀	-	"	10-27-64	"	Lehner
Sterna sumatrana	" 494591	♂	-	Enego	10-25-64	"	Huber
" "	" 494592	♀	-	Aradojairik	10-26-64	"	"
" "	" 494593	♂	-	"	"	"	"
" "	" 494594	♂	-	"	"	"	"
" "	" 494595	♀	-	"	"	"	"
" "	" 494596	♀	chick	"	10-27-64	"	Amerman
" "	" 494597	♂	"	"	"	"	"
Anous stolidus	" 494656	♂	"	Loj	10-25-64	"	Huber
" "	" 494657	♀	-	Enego	"	"	"
" "	" 494658	♂	-	Jabonwar	10-26-64	"	Clapp
" "	" 494659	♂	-	Aradojairen	"	"	Huber
" "	" 494660	♀	-	"	"	"	"
" "	" 494661	♂	-	"	"	"	"
" "	" 494662	♂	-	Bogengoa	10-27-64	"	Lehner
" "	" 543414	?	SA	Erikub I	5-4-67	"	Amerson
" "	" 543415	?	I	Bogengoa	"	"	"
" "	" 543473	♂	A	Erikub I	"	"	"
" "	" 543474	♀	A	Bogengoa	"	"	"
Anous tenuirostris	" 494539	♂	-	Loj	10-24-64	"	Huber
" "	" 494540	♀	-	"	10-25-64	"	"
" "	" 494541	-	-	"	"	"	"
" "	" 494542	♀	-	"	"	"	Wislocki
" "	" 494543	♀	-	"	"	"	Huber
" "	" 494544	♂	-	Enego	"	"	Clapp
" "	" 494545	♀	-	"	"	"	Huber
" "	" 494546	♂	-	"	"	"	Lehner
" "	" 543499	♂	A	Bogengoa	5-4-67	"	Amerson
" "	" 543440	♀	A	"	"	"	"
" "	" 543441	♀	A	"	"	"	"
" "	" 543442	♀	A	Erikub I	"	"	"
" "	" 543495	♂	A	"	"	"	"
Gygis alba	" 494628	♀	-	Loj	10-24-64	"	Clapp
" "	" 494629	♀	-	"	"	"	Wislocki
" "	" 494630	♂	-	"	"	"	Huber
" "	" 494631	♀	-	Aradojairik	10-27-64	"	"
" "	" 543498	♀	A	Bogengoa	5-4-67	"	Amerson

Species Accounts

1) <u>Phaethon rubricauda</u> Red-tailed Tropicbird

Habitat -- 27 October 1964 - flying over Erikub Island.

Numbers -- 27 October 1964 - one observed on Erikub; May 1967 - Erikub and Bogengoa none observed.

Status -- Resident breeder? Possible breeder but no breeding activity observed.

Specimen Records -- None. This is a new species sight record for Erikub Atoll.

2) <u>Phaethon lepturus</u> White-tailed Tropicbird

Habitat -- October 1964 - observed flying over Enego, Aradojairen, and Bogengoa, reported nesting in a tree on Enego by a visiting native; May 1967 - observed flying above Bogengoa.

Numbers -- October 1964 - Enego 4, Aradojairen 1, Bogengoa 1; May 1967 - Bogengoa 2.

Status -- Resident breeder. October 1964 - no nest observed, but one half-grown chick was seen which visiting natives said came from Enego (they had collected it to eat); May 1967 - in-flight courtship behavior observed. This is a new breeding record for the atoll.

Specimen Records -- Other - none; POBSP - one (Table 10). This is a new species and specimen record from Erikub Atoll.

3. <u>Sula sula</u> Red-footed Booby

Habitat -- October 1964 - seen offshore (at sea) of Erikub Island on 26 October, attempting to roost in <u>Pisonia</u> tree on Aradojairik on 27 October.

Numbers -- October 1964 - Erikub 1, Aradojairik 1.

Status -- Resident breeder? Possible breeder but no evidence of breeding.

Specimen Records -- None. This is a new sight record for Erikub Atoll.

4. <u>Sula leucogaster</u> Brown Booby

Habitat -- October 1964 - flying offshore of Loj, roosting (daytime) on Bogengoa, nesting and roosting on windward (east) side of

Aradojairik - nests, built of sticks and leaves, placed on open ground (coral rock and humus) under *Pisonia* and *Cocos* trees; May 1967 - adults and immatures observed flying over the lagoon on southwest side.

Numbers -- October 1964 - Loj 1, Bogengoa 1, Aradojairik 200; May 1967 - over lagoon 10; number banded 46.

Status -- Resident breeder. October 1964 - Aradojairik Island, approximately 75 nests (about 1/2 with eggs, 1/4 with chicks, and 1/4 prelaying). This is a new breeding record.

Specimen Records -- Other - none; POBSP - 10 (Table 10). This is a new species and specimen record for the atoll.

5) *Fregata minor* Great Frigatebird

Habitat -- October 1964 - flying over Erikub, Loj, Enego, Aradojairen, and Bogella, roosting in *Pisonia* trees on Aradojairik; May 1967 - adults and immatures flying above the lagoon and Erikub and Bogengoa.

Numbers -- October 1964 - one on all the above islands except Aradojairik which had 75 (Table 11); May 1967 - Erikub 2, Bogengoa 4, above lagoon 5.

Status -- Resident breeder? Possible breeder but no evidence of breeding.

Specimen Records -- Other - none; POBSP - 1 (Table 10). This is a new species and specimen record for Erikub Atoll.

6) *Fregata ariel* Lesser Frigatebird

Habitat -- May 1967 - flying above Erikub and Bogengoa, males only.

Numbers -- May 1967 - Erikub 1, Bogengoa 2.

Status -- Resident breeder? May 1967 - possible breeder but no evidence of breeding.

Specimen Records -- None. All attempts to collect a specimen failed. This observation constitutes a new species sight record for Erikub Atoll.

7) *Egretta sacra* Reef Heron

Habitat -- October 1964 - present on all islands except Aradojairen, Jabonwar, Bogella, and Bokku - seen mainly on exposed coral rock on seaward sides of each island, occasionally found on lagoon beaches; May 1967 - rocky seaward beach of Erikub and Bogengoa.

Table 11. Bird Population Estimates for Islands of Erikub Atoll October 24-28, 1964 (asterisks indicate nesting).

Species	Erikub	Loj	Enego	Aradojairen	Jabonwar	Aradojairik	Guro	Jeldoni	Bogella	Jogan	Bogweido	Bokku	Bogengoa
White-tailed Tropicbird	-	-	2*	-	-	-	-	-	-	-	-	-	-
Red-tailed Tropicbird	1	-	-	-	-	-	-	-	-	-	-	-	-
Brown Booby	-	1	-	-	-	200*	-	-	-	-	-	-	1
Red-footed Booby	1	-	-	-	-	-	-	-	-	-	-	-	-
Great Frigatebird	1	1	1	1	-	75	-	-	1	-	-	-	-
Reef Heron	4	1	1	-	-	1	1	1	-	1	1	-	1
Snow Goose	1	-	-	-	-	-	-	-	-	-	-	-	-
Golden Plover	5	20-30	60-70	15-20	1	14	4	8	5	5	5	-	10
Ruddy Turnstone	20	25-35	75	10-20	10-12	10	5	4	10	10	10	-	15
Bristle-thighed Curlew	3	15-20	40-50	1	1	-	3	8	-	3	-	-	10
Wandering Tattler	25	2	-	3	-	1	3	6	2	2	2	2	20
Sanderling	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-naped Tern	-	-	2	-	2	25*	2	-	-	-	-	4	3
Crested Tern	-	1	-	3	2	2	-	-	-	-	-	-	-
Brown Noddy	30	5-10	100	25-50	5-10	-	-	-	-	-	-	-	75-100
Black Noddy	20*	25-50	150-250*	100-200*	100-150*	20-40	45-50*	30	50-75*	50-75*	50-75*	-	400*
White Tern	200*	300-500*	400-500*	300-400*	250*	200*	30-35*	100	10	100-150*	100-150*	1	2000*

Numbers -- October 1964 - usually one on each island, except four on Erikub (Table 11); May 1967 - Erikub 2, Bogengoa 5.

Status -- Resident breeder? No evidence of breeding, however, there is a possibility that this species breeds on Erikub Atoll.

Specimen Records -- Other - none; POBSP - 3 (Table 10). This collection constitutes a new species and specimen record for Erikub Atoll.

8) Chen hyperborea Snow Goose

Habitat -- 27 October 1964 - sitting on seaward beach of Erikub Island.

Number -- 27 October 1964 - one seen and collected on Erikub Island.

Status -- Accidental.

Specimen Records -- Other - none; POBSP - 1 (Table 10). This is a new species and specimen record for all of Micronesia.

9) Pluvialis dominica Golden Plover

Habitat -- October 1964 - observed on sandy and rocky beaches of all islands except Bokku; May 1967 - recorded on sandy lagoon beaches and rocky seaward beaches of Erikub and Bogengoa.

Numbers -- October 1964 - total observed 177, range 1-70 per island (Table 11 for numbers found on each island); May 1967 - Erikub 5, Bogengoa 10.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - 1 (Table 10). This specimen represents a new species and specimen record for Erikub Atoll.

10) Numenius tahitiensis Bristle-thighed Curlew

Habitat -- October 1964 - present on sandy and rocky beaches of all islands except Aradojairik, Bogella, Bogweido, and Bokku; May 1967 - on rocky seaward beaches of Erikub and Bogengoa.

Numbers -- October 1964 - total population 84-99, range 1-50 per island (see Table 11 for population from each island); May 1967 - Erikub 2, Bogengoa 4.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - 1 (Table 10). This is a new species and specimen record for Erikub Atoll.

11) *Heteroscelus incanum* Wandering Tattler

Habitat -- October 1964 - present on seaward beaches of all islands except Enego and Jabonwar; May 1967 - on rocky beaches of Erikub and Bogengoa.

Numbers -- October 1964 - total population 63-68, range 1-25 per island (see Table 11 for population estimate from each island); May 1967 - Erikub 3, Bogengoa 5.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - 4 (Table 10). These specimens represent a new species and specimen record for Erikub Atoll.

12) *Arenaria interpres* Ruddy Turnstone

Habitat -- October 1964 - present on sandy and rocky beaches of all islands except Bokku; May 1967 - on sand and coral rock beaches of Erikub and Bogengoa.

Numbers -- October 1964 - total population 204-226, range 4-75 per island (Table 11 for population of each island); May 1967 - Erikub 6, Bogengoa 8.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - 3 (Table 10). This Ruddy Turnstone collection represents a new species and specimen record for Erikub Atoll.

13) *Crocethia alba* Sanderling

Habitat -- 27 October 1964 - sandy beach of Bogengoa.

Numbers -- 27 October 1964 - only one seen during entire visit to Erikub Atoll.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - 1 (Table 10). This is a new species and specimen record for Erikub Atoll.

14) *Sterna sumatrana* Black-naped Tern

Habitat -- October 1964 - roosting on sandy beach of Enego, Jabonwar, Aradojairik, Guro, Bokku, and Bogengoa; nesting on bare coarse pebbles of upper beach (next to vegetation, west side) on Aradojairik; May 1967 - adults observed flying above the southwest portion of the lagoon.

Numbers -- October 1964 - Enego 2, Jabonwar 2, Guro 2, Bogengoa 4, Aradojairik 25; May 1967 - lagoon 10.

Status -- Resident breeder. October 1964 - Aradojairik 4 nests (2 with eggs, 2 with half-grown chicks), Guro 2 adults appeared to have a nest but none could be found. This is a new breeding record for Erikub Atoll.

Specimen Record -- Other - none; POBSP - 7 (Table 10). These Black-naped Terns represent a new species and specimen record for Erikub Atoll.

15) *Thalasseus bergii* Crested Tern

Habitat -- October 1964 - roosting on and flying over sand bars of Loj, Aradojairen, Jabonwar, Aradojairik; May 1967 - adults observed on sand and rocky beaches of Erikub and Bogengoa, also flying over the lagoon.

Numbers -- October 1964 - Loj 1, Aradojairen 3, Jabonwar 2, and Aradojairik 2; May 1967 - Erikub 2, Bogengoa 3, lagoon 5.

Status -- Resident breeder? May possibly breed but no breeding activity observed.

Specimen Records -- None. This observation constitutes a new species sight record for Erikub Atoll.

16) *Anous stolidus* Brown Noddy

Habitat -- October 1964 - roosting in *Pisonia* trees and on the beaches of Erikub, Bogengoa, Loj, Enego, Aradojairen, and Jabonwar; May 1967 - roosting and nesting in *Cocos* trees on Erikub and Bogengoa, also flying above the lagoon.

Numbers -- October 1964 - total population 240-300, range 10-100 per island (see Table 11 for estimates for each island); May 1967 - Erikub 200, Bogengoa 300, lagoon 100.

Status -- Resident breeder. October 1964 - not breeding; May 1967 - eggs to fledglings present. This is a new breeding record for the atoll.

Specimen Records -- Others - none; POBSP - 11 (Table 10). This is a new species and specimen record for Erikub Atoll.

17) *Anous tenuirostris* Black Noddy

Habitat - October 1964 - roosting and flying over all islands except Bokku; nesting in tops of *Pisonia* trees on Erikub, Enego, Aradojairen, Jabonwar, Guro, Bogella, Jogan, Bogweido, and Bogengoa; May 1967 - roosting and nesting in tops of *Pisonia* trees at Erikub and Bogengoa, also flying over lagoon.

348-415 O-69—7

Numbers -- October 1964 - very common on all islands except Bokku, total atoll population 1,040-1,415, range 20-400 per island (Table 11 for population estimate for each island); May 1967 - Erikub 300, Bogengoa 500, lagoon 200.

Status -- Resident breeder. October 1964 - old and new nests present, eggs to almost fledged young found; Loj - several old nests seen, Enego - several adults seen on nests, Aradojairen - old nests and nests with young present, Jabonwar - two adults seen on nests and other 30± nests found (some containing large young), Guro - 10+ nests seen, Bogella - old nests present, Jogan - several old nests observed, Bogweido - old nests found, Bogengoa - many nests seen, Erikub - very few nests observed; May 1967 - a few active nests present on Erikub and Bogengoa. This is a new breeding record for the atoll.

Specimen Records -- Other - none; POBSP - 13 (Table 10). These *Anous tenuirostris* represent a new species and specimen record for Erikub Atoll.

18) *Gygis alba* White Tern

Habitat -- October 1964 - observed roosting and flying over all islands except Bokku, eggs placed directly on branches of trees (mainly *Pisonia*); May 1967 - roosting in *Pisonia* at Erikub and Bogengoa, also flying over islands and lagoon.

Numbers -- October 1964 - most abundant bird on Erikub Atoll, total population 4,080-4,585, range 30-2,000 per island (see Table 11 for population on each island); May 1967 - Erikub 300, Bogengoa 400, lagoon 200.

Status -- Resident breeder. October 1964 - nesting on all islands except Bokku, many eggs present, few chicks observed; May 1967 - no nests observed, specimen collected had bare brood patch. This is a new breeding record for the atoll.

Specimen Record -- Other - none; POBSP - 5 (Table 10). These constitute a new species and specimen record for Erikub Atoll.


170°50'E
170°55'
171°00'
171°05'
171°10'
171°15'
08°55'N
08°50'
08°45'
08°40'
08°35'
Bwokwentarinae
Kaven
Yarabaru
Bwokwloboea
Onimak
Anemwaan
Enea
Marere
Enemejiken
Talto
Tjan
Alngaden
Tar
Jedko
Kedjebe
Nawoj
Ollot
Bikat
Jenmaanlokw
Taroa
Reuter
Ajilien
Boklaplap
Eien
Bwokwankin
Egeriben
Kemar
Bwokwanajdomw
Bwokwaang
Bwokwaddel
Airik
Makar
Bwokwen
Bogen
Bebi
Jebjatiti
Bwokwanajinwir
Bwokwankeer
Bwokwanrjinwir
Bogenagak
Bwokwalurito
Loa
Enibin
Enijun
MALOELAP
0 1 2 3 4 5
STATUTE MILES

MALOELAP ATOLL

Location: 08°45' N x 171°03' E.

Shape and Size: Elongated triangle-shaped; Tip (pointed northwest) to base (southeast side) - 32 miles; Widest point (near base) - 16 miles; Total lagoon area - 388.48 square miles; Total dry land area - 3.81 square miles; Number of islands - 89; Height - 10 to 15 feet (Fosberg, 1956; U.S. Navy, 1964).

Soil: No available data. Said to be most fertile of all the Marshall Islands (Fosberg, 1956).

Vegetation: Eleven known species; more luxuriantly vegetated than most Marshall Islands; abundant Cocos, Artocarpus, and Pandanus (Wiens, 1957; Fosberg, 1956).

Climate: Moderately wet to wet, about 100 inches of rainfall yearly; Mean air temperature - 82° F., Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 1,000 in mid 1800's (Findlay, 1886); 457 in 1948 (Freeman, 1951); Present - inhabited, 636 in 1964 (U.S. Department of State, 1965).

Scientific Visits: Japanese visit (H. Orii) 13-14 September 1931; Pacific Science Board (H. J. Wiens) summer 1956.

Avifauna: Five species of birds are known from Maloelap Atoll. These 5 species include 1 seabird, 2 shorebirds, a heron, and a domestic fowl. No birds are known to breed on the atoll; however, 3 species are potential breeders.

A checklist of the bird species recorded on Maloelap Atoll follows. The source material for this list includes: (1) Baker, 1951; (2) Hand-list of Japanese birds, (a) 1932, (b) 1942, (c) 1958; (3) Yale Cross-Cultural Survey, 1943; and (4) YIZM collection. These sources are referred to in the checklist by the corresponding numbers and letters.

Maloelap Atoll Avifauna Checklist

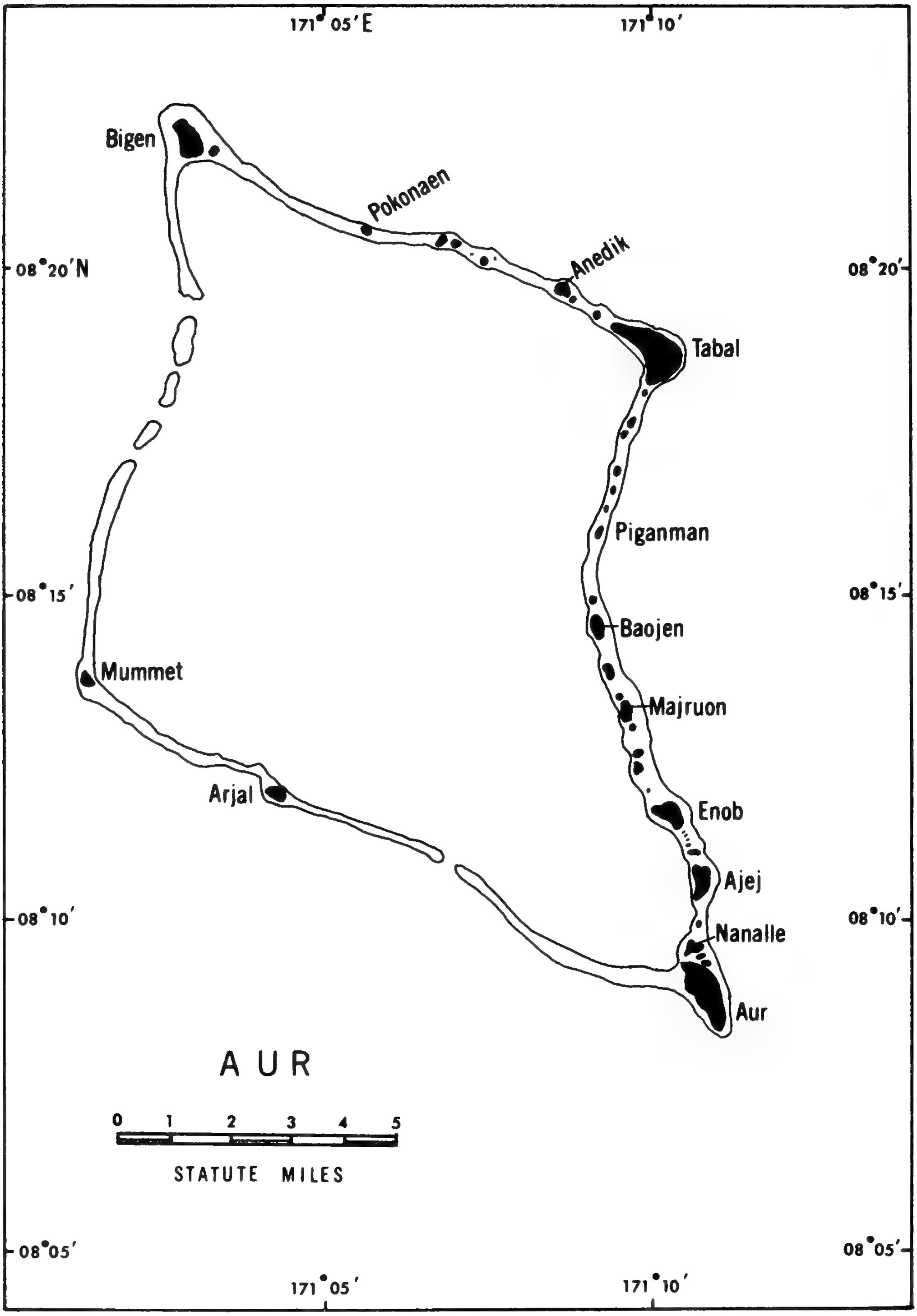
Species	Status	Source
1) *Egretta sacra*	Resident breeder ?	1, 2b, 4
2) *Gallus gallus*	Introduced breeder ?	3
3) *Numenius tahitiensis*	Migrant	1, 2b, 4
4) *Heteroscelus incanum*	Migrant	1, 2b
5) *Thalasseus bergii*	Resident breeder ?	1, 2ab, 4

Bird specimens collected from Maloelap Atoll include 12 specimens of three species, all of which are located in the Yamashina collection in Tokyo, Japan.

TABLE 12. Bird specimens collected from Maloelap Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Egretta sacra	YIZM	♂	Juv	Maloelap I*	09-14-31	Skin	H. Orii
Numenius tahitiensis	YIZM	♂	-	"	"	"	"
" "	YIZM	♂	-	"	"	"	"
" "	YIZM	♂	A	"	"	"	"
" "	YIZM	♀	-	"	09-13-31	"	"
" "	YIZM	♀	-	"	09-14-31	"	"
" "	YIZM	♀	-	"	"	"	"
" "	YIZM	♀	-	"	"	"	"
" "	YIZM	♀	-	"	"	"	"
Thalasseus bergii	YIZM	♂	-	"	09-13-31	"	"
" "	YIZM	♂	Juv	"	"	"	"
" "	YIZM	♀	-	"	"	"	"

*Probably Kaven Island



171° 05′E
171° 10′
08° 20′N
08° 20′
08° 15′
08° 15′
08° 10′
08° 10′
08° 05′
08° 05′
171° 05′
171° 10′
Bigen
Pokonaen
Anedik
Tabal
Piganman
Baojen
Majruon
Enob
Ajej
Nanalle
Aur
Mummet
Arjal
A U R
0 1 2 3 4 5
STATUTE MILES

AUR ATOLL

Location: 08°16' N x 171°06' E.

Shape and Size: Roughly diamond-shaped; Tip to tip (northwest-southeast) - 15 miles; Widest point (northeast-southwest) - 9 miles; Total lagoon area - 92.58 square miles; Total dry land area - 2.17 square miles; Number of islands-42; Height - 8 feet (Freeman, 1951; U.S. Navy, 1964).

Soil: No available data.

Vegetation: One species known; *Cocos* common, most islands are wooded (Findlay, 1886; U.S. Navy, 1964).

Climate: Wet, about 100-120 inches of rainfall yearly; Mean air temperature-82° F.; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 1,000 in mid 1800's (Findlay, 1886); 418 in 1948 (Freeman, 1951); Present - inhabited, 372 in 1964 (U.S. Department of State, 1965).

Scientific Visits: Japanese Expedition (H. J. Orii and S. Kawakami) 13, 25, 26 September 1931, 6 January 1933.

Avifauna: Seven species of birds have been recorded from Aur Atoll. These include 5 seabirds, 1 cuckoo, and 1 domestic fowl. None are known to breed but 6 species are potential breeders. One species, the cuckoo, is migratory.

The known bird species from Aur Atoll are included in the following checklist. Source material for this list includes: (1) Baker, 1951; (2) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (3) Yale Cross-Cultural Survey, 1943; (4) Bogert, 1937; and (5) YIZM collection. These sources are referred to in the checklist by the corresponding numbers and letters.

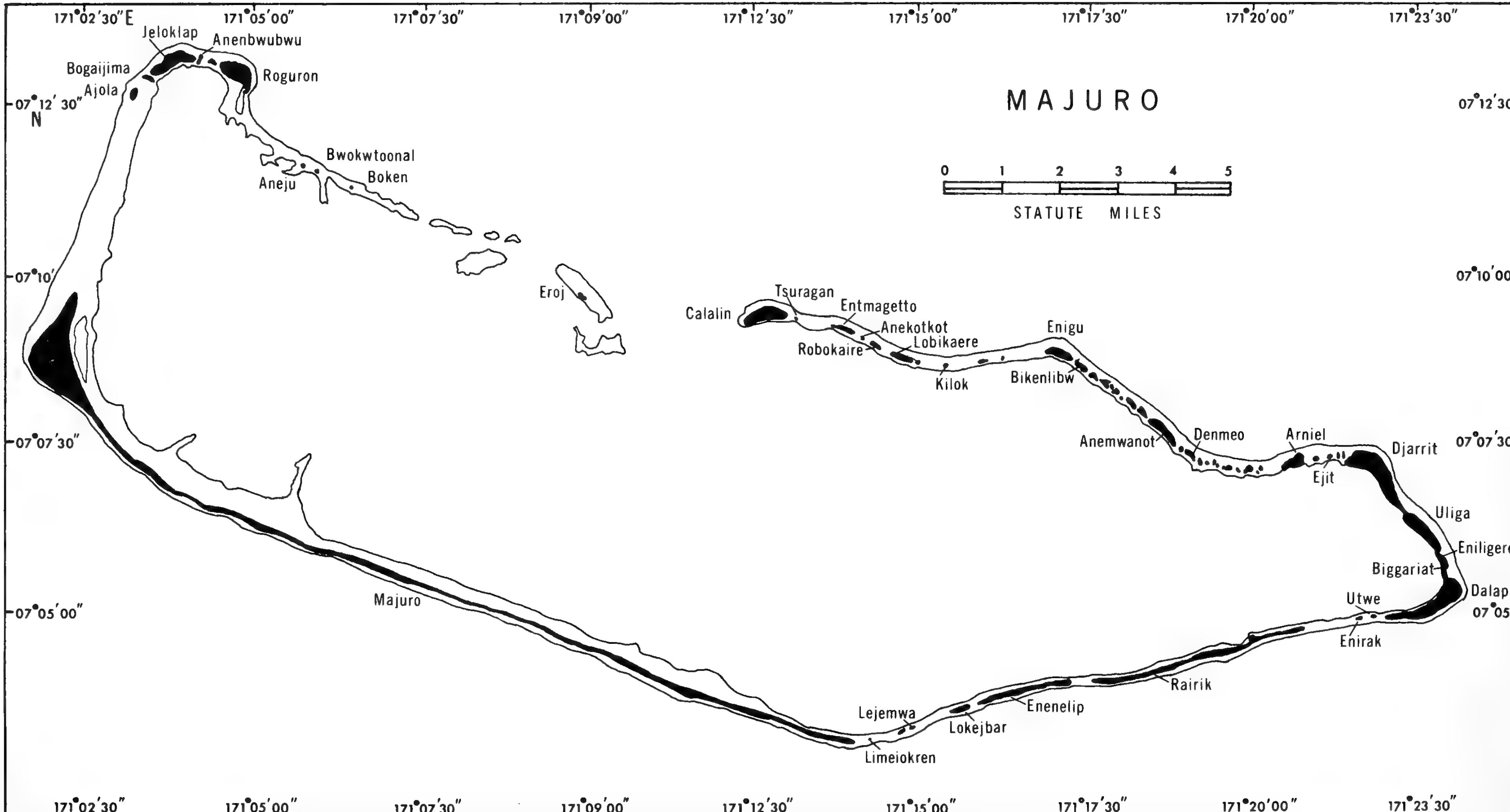
Aur Atoll Avifauna Checklist

Species	Status	Source
1) *Gallus gallus*	Introduced breeder ?	3
2) *Sterna sumatrana*	Resident breeder ?	1, 2ab, 5
3) *Thalasseus bergii*	Resident breeder ?	1, 2ab, 5
4) *Anous stolidus*	Resident breeder ?	1, 2ab, 5
5) *Anous tenuirostris*	Resident breeder ?	1, 2ab, 5
6) *Gygis alba*	Resident breeder ?	1, 2ab, 5
7) *Urodynamis taitensis*	Migrant	1, 2ab, 4, 5

Bird specimens collected from Aur Atoll include 18 specimens of 6 species, all in the Yamashina collection.

TABLE 13. Bird specimens collected from Aur Atoll.

Species		Museum	Sex	Age	Location	Date	Status	Collector
Sterna	sumatrana	YIZM	♂	A	Aur I	09-26-31	Skin	H. Orii
"	"	YIZM	♂	A	"	"	"	"
"	"	YIZM	♀	A	"	"	"	"
"	"	YIZM	♀	A	"	"	"	"
"	"	YIZM	♀	A	"	"	"	"
Thalasseus	bergii	YIZM	♂	A	"	"	"	"
"	"	YIZM	♀	Juv	"	"	"	"
Anous	stolidus	YIZM	♂	Juv	"	"	"	"
"	"	YIZM	♂	A	"	"	"	"
"	"	YIZM	♂	A	"	"	"	"
"	"	YIZM	♂	A	"	"	"	"
Anous	tenuirostris	YIZM	♂	A	"	09-25-31	"	"
Gygis	alba	YIZM	-	N	"	09-26-31	"	"
"	"	YIZM	♂	A	"	"	"	"
"	"	YIZM	♀	A	"	09-13-31	"	"
"	"	YIZM	♀	A	"	09-26-31	"	"
Urodynamis	taitensis	YIZM	♀	A	Aur I	09-25-31	"	"
"	"	YIZM	♀	A	"	01-06-33	"	S. Kawakami


MAJURO
0 1 2 3 4 5
STATUTE MILES
171°02'30"E
171°05'00"
171°07'30"
171°09'00"
171°12'30"
171°15'00"
171°17'30"
171°20'00"
171°23'30"
07°12'30"N
07°10'
07°07'30"
07°05'00"
07°12'30"
07°10'00"
07°07'30"
07°05'
Jeloklap
Anenbwubwu
Bogaijima
Ajola
Roguron
Bwokwtoonal
Boken
Aneju
Eroj
Calalin
Tsuragan
Entmagetto
Anekotkot
Robokaire
Lobikaere
Kilok
Enigu
Bikenlibw
Anemwanot
Denmeo
Arniel
Ejit
Djarrit
Uliga
Eniligere
Biggariat
Dalap
Utwe
Enirak
Rairik
Enenelip
Lokejbar
Lejemwa
Limeiokren
Majuro

MAJURO ATOLL

Location: 07°09' N x 171°12' E.

Shape and Size: Irregular rectangle-shaped; Tip to tip (east-west) - 30 miles; Widest point (north-south) - 10 miles; Total lagoon area - 113.92 square miles; Total dry land area - 3.54 square miles; Number of islands - 57; Height - 8-10+ feet (Doran, 1959; U.S. Navy, 1964).

Soil: No available data.

Vegetation: Nine species known; most islands with moderate to heavy cover of *Cocos*. Other vegetation includes: *Scaevola*, *Messerschmidia*, *Wedelia*, *Ipomea*, *Pandanus*, and *Artocarpus* (Doran, 1959; U.S. Navy, 1964).

Climate: Very wet, about 140 inches of rainfall yearly; Mean air temperature-82° F.; Wind - prevailing from east and southeast (Fosberg, 1956; U.S. Navy, 1964).

Human Population: Past - inhabited, 1,500 to 3,000 in mid 1800's (Findlay, 1886), 1,473 in 1948 (Freeman, 1951); Present - inhabited, 4,612 in 1964 (U.S. Department of State, 1965).

Scientific Visits: Japanese Expedition (H. Orii) 12,27 September 1931; POBSP - 10-12 June 1966.

Avifauna: Fifteen bird species are known from Majuro Atoll. Of these 15, 7 are seabirds, 5 are shorebirds, 1 is a heron, 1 is a domestic fowl, and 1 is a parrot. None of the bird species are known to breed on Majuro Atoll; however, 9 are considered to be potential breeders.

Dayle Husted, of the POBSP visited Majuro Atoll on 10 and 11 June 1966 while aboard the U.S. Coast Guard Cutter *Basswood*. Due to lack of time (arrived 0800 on the 10th, departed 1300 on the 11th) and no means of travel, only the main island and one nearby small island were surveyed. Bird observations were limited to a few sight observations; no birds were nesting. Thus, the normal annotated species accounts will not be given.

The following checklist presents the known bird species from Majuro Atoll. The sources for this checklist include: (1) POBSP band recovery; (2) POBSP field data, 1966; (3) Baker, 1951; (4) Hand-list of Japanese Birds, (a) 1932, (b) 1942, and (c) 1958; (5) Yale Cross-Cultural Survey, 1943; (6) MCZ collection; and (7) YIZM collection. These sources are referred to in the checklist by the corresponding numbers and letters. The seven species marked with an asterisk are new species sight records for Majuro Atoll.

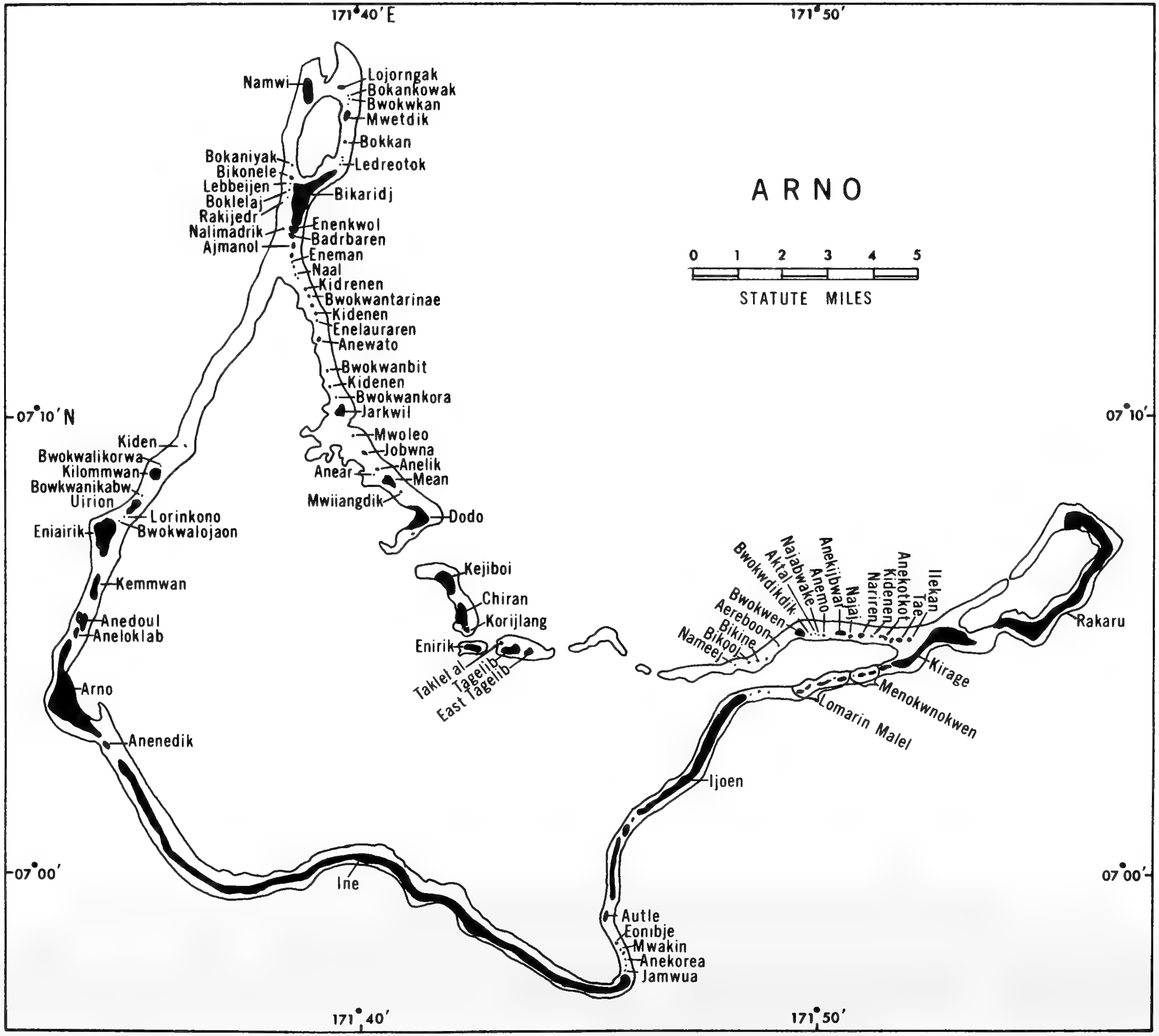
Majuro Atoll Avifauna Checklist

Species	Status	Source
1) Sula sula*	Resident breeder ?	2
2) Sula leucogaster*	Resident breeder ?	1, 2
3) Egretta sacra	Resident breeder ?	3, 4ab, 7
4) Gallus gallus	Introduced breeder ?	5
5) Pluvialis dominica	Migrant	3, 4abc, 7
6) Charadrius mongolus	Migrant	3, 4ab, 7
7) Numenius tahitiensis	Migrant	4ab
8) Heteroscelus incanum	Migrant	4bc, 7
9) Arenaria interpres	Migrant	1, 3, 4abc, 7
10) Sterna sumatrana	Resident breeder ?	2, 4abc, 6, 7
11) Thalasseus bergii*	Resident breeder ?	2
12) Anous stolidus*	Resident breeder ?	2
13) Anous tenuirostris*	Resident breeder ?	2
14) Gygis alba*	Resident breeder ?	2
15) Parrot*	Introduced ?	2

Bird specimens taken at Majuro Atoll include 14 specimens of 6 species. All of the specimens, but one, are located in the Yamashina Institute for Zoology and Ornithology Museum, Tokyo, Japan.

TABLE 14. Bird specimens collected from Majuro Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Egretta sacra	YIZM	♂	A	Majuro I	09-12-31	Lost	H. Ori
" "	YIZM	♂	A	"	"	Skin	"
" "	YIZM	♂	A	"	09-27-31	"	"
" "	YIZM	♂	A	"	"	Lost	"
Pluvialis dominica	YIZM	♀	A	"	09-12-31	Skin	"
" "	YIZM	♂	A	"	"	"	"
Charadrius mongolus	YIZM	♀	-	"	09-27-31	"	"
Heteroscelus incanum	YIZM	♀	A	"	"	Lost	"
" "	YIZM	♀	A	"	"	Skin	"
" "	YIZM	♀	A	"	"	Lost	"
Arenaria interpres	YIZM	♀	-	"	09-12-31	Skin	"
Sterna sumatrana	YIZM	♂	A	"	"	"	"
" "	YIZM	♀	A	"	"	"	"
" "	MCZ 264056	♀	-	Majuro	??	"	-



ARNO
0 1 2 3 4 5
STATUTE MILES
171°40′E
171°50′
171°40′
171°50′
07°10′N
07°00′
07°10′
07°00′
Namwi
Lojorngak
Bokankowak
Bwokwkan
Mwetdik
Bokkan
Ledreotok
Bokaniyak
Bikonele
Lebbeijen
Boklelaj
Rakijedr
Nalimadrik
Ajmanol
Bikaridj
Enenkwol
Badrbaren
Eneman
Naal
Kidrenen
Bwokwantarinae
Kidenen
Enelauraren
Anewato
Bwokwanbit
Kidenen
Bwokwankora
Jarkwil
Mwoleo
Jobwna
Anelik
Anear
Mean
Mwiiangdik
Dodo
Kiden
Bwokwalikorwa
Kilommwan
Bowkwanikabw
Uirion
Lorinkono
Eniairik
Bwokwalojaon
Kemmwan
Anedoul
Aneloklab
Arno
Anenedik
Ine
Kejiboi
Chiran
Korijlang
Enirik
Takleł al
Tagelib
East Tagelib
Bwokwdikdik
Aktal
Najabwake
Anemo
Anekijbwar
Najaj
Nariren
Kidenen
Anekotkot
Tae
Ilekan
Bwokwen
Aereboon
Bikine
Bikool
Nameej
Rakaru
Kirage
Menokwnokwen
Lomarin Malel
Ijoen
Autle
Eonibje
Mwakin
Anekorea
Jamwua

ARNO ATOLL

Location: 07°05' N x 171°41' E.

Size and Shape: Irregular rectangle-shaped; Tip to tip (northwest-southeast) - 21 miles; Widest point (northeast-southwest) - 6-15 miles; Total lagoon area - 130.77 square miles; Total dry land area - 5.00 square miles; Number of islands-133; Height - 6 to 8 feet (Freeman, 1951; U.S. Navy, 1964).

Soil: Beach (ocean side) - mainly cobblestone; Beach (lagoon side) - mainly sandy; Interior - stony, loamy sand, some dark soil (Stone, 1951).

Vegetation: 126 species; Many *Cocos* trees and dense vegetation on most islands, some mangrove swamp (Anderson, 1951).

Climate: Wet, about 100-120 inches of rainfall yearly; Mean air temperature-82° F., Wind - prevailing from east (Cox, 1951 ; Fosberg, 1956; U.S. Navy 1964).

Human Population: Past - inhabited, 3,000 in 1882 (Findlay, 1886), 1,071 in 1948 (Freeman, 1951); Present - inhabited, 1,301 in 1964 (U.S. Department of State, 1965).

Scientific Visits: Japanese Expeditions - September 1931, April 1933; Townsend-January 1900; SIM Project, Pacific Science Board - 8 June-12 September 1950; Pacific Science Board (H. J. Wiens) - summer 1956.

Avifauna: Fifteen bird species have been recorded from Arno Atoll. These 15 species include 6 seabirds, 5 shorebirds, 1 heron, 1 domestic fowl, a pigeon, and a cuckoo. Five of the species are known breeders on the atoll, while 3 species are potential breeders. The type locality for *Ducula oceanica ratakensis* is Arno Atoll.

The following checklist presents those bird species known to occur at Arno Atoll. The sources used to compile this list include: (1) Marshall, (a) 1951, (b) 1957; (2) Yamashina, (a) 1932, (b) 1940; (3) POBSP band recovery; (4) Finsch, (a) 1880d,(b) 1884; (5) Townsend and Wetmore, 1919; (6) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (7) Yale Cross-Cultural Survey, 1943; (8) Takatsukasa and Yamashina, 1932;(9) Wiglesworth, 1891; (10) Momiyama, 1922; (11) Matthews, 1933; (12) Amadon, 1943; (13) Mayr, 1945; and (14) Baker, 1951. These sources are referred to in the checklist by the corresponding numbers and letters.

Arno Atoll Avifauna Checklist

Species	Status	Source
1) *Puffinus tenuirostris*	Accidental	2b, 6b, 14
2) *Egretta sacra*	Resident breeder, July	1ab, 6ab, 14

Species	Status	Source
3) Gallus gallus	Introduced breeder ?	1a, 7
4) Pluvialis dominica	Migrant	1a, 5, 6ab, 14
5) Numenius tahitiensis	Migrant	1a, 4a, 14
6) Limosa lapponica	Migrant	1a, 6b, 14
7) Heteroscelus incanum	Migrant	1a, 4b, 6b, 14
8) Arenaria interpres	Migrant	1a, 3
9) Sterna sumatrana	Resident breeder, spring (?), Sep., few	1a, 2a, 5, 6ab, 14
10) Thalasseus bergii	Resident breeder, spring (?); few	1a
11) Anous stolidus	Resident breeder (?) Many	1a, 14
12) Anous tenuirostirs	Resident breeder, spring; Many	1a, 14
13) Gygis alba	Resident breeder (?);few	1a, 14
14) Ducula oceanica ratakensis	Resident breeder, July;	1ab, 4a, 6ab, 8, 9, 10, 11, 12, 13, 14
15) Urodynamis taitensis	Migrant, summer; few	1a

Bird specimens collected at Arno Atoll includes 35 specimens of 12 species. These are located in three museums, Yamashina Institute for Zoology and Ornithology Museum, U. S. National Museum, and Museum of Comparative Zoology at Harvard. Some of J. T. Marshall's specimens have not been located.

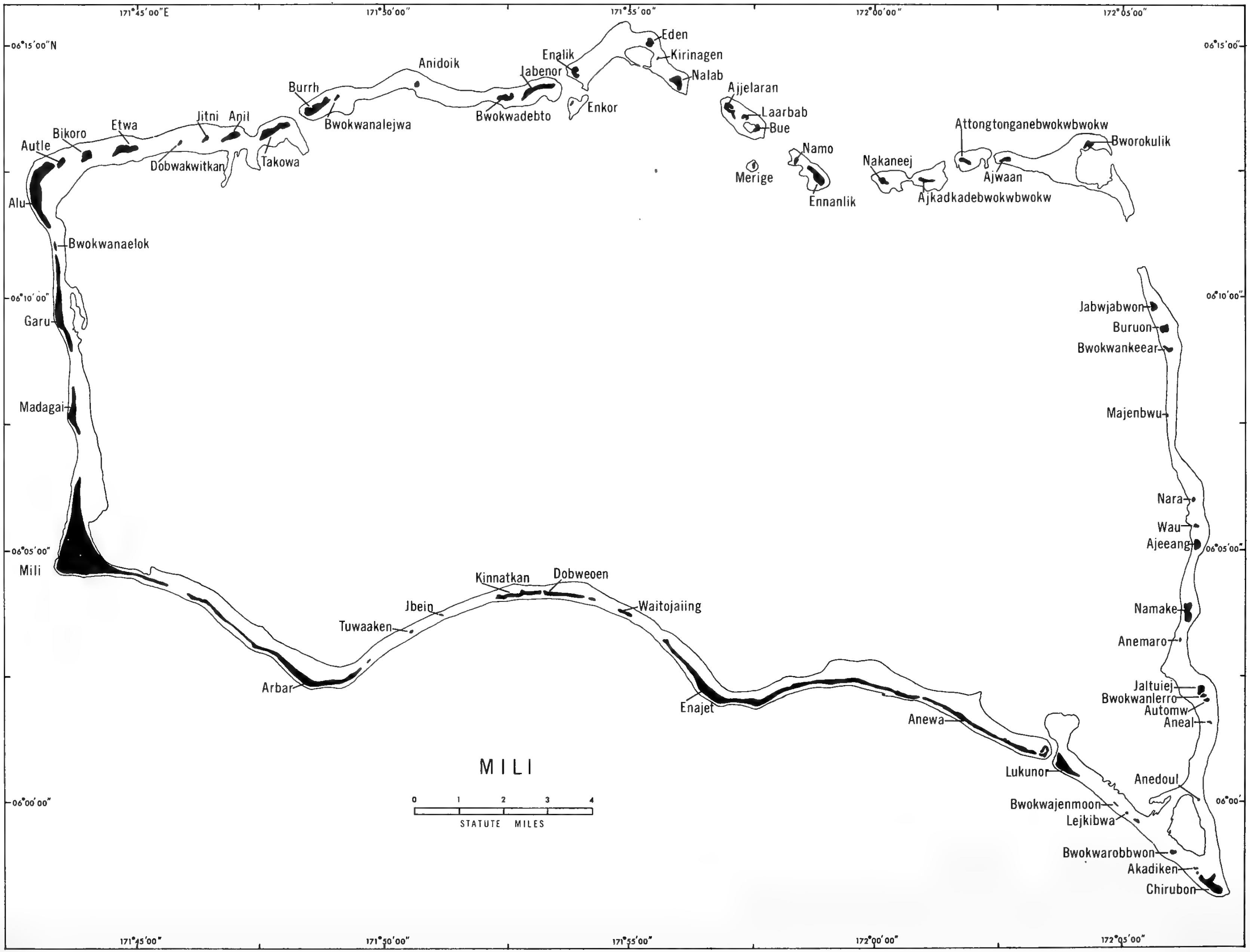
TABLE 15. Bird specimens collected from Arno Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Puffinus tenuirostris	YIZM	♀	A	Ine	04-21-33	Skin	S. Kawakami
Egretta sacra	MCZ	♂	A	Arno I	09-28-31	"	-
" "	YIZM	♂	A	"	"	Lost	H. Orii
" "	YIZM	♂	Juv	"	"	"	"
" "	YIZM	♀	A	"	"	"	"
" "	YIZM	♀	A	"	"	Skin	"
" "	?	♀	A	"	07-17-50		J.Marshall,Jr
Pluvialis dominica	USNM 212230	♀	-	-	01-25-00	"	C.Townsend
" "	USNM 212231	♂	-	-	"	"	"
" "	MCZ 81923	♀	-	Arno	"	"	"
" "	?			"			J.Marshall,Jr
Heteroscelus incanum	YIZM	♀	A	"	09-28-31	Skin	H. Orii
Arenaria interpres	?						J.Marshall,Jr
Sterna sumatrana	USNM 212143	♂	Juv	-	01-26-00	"	C.Townsend
" "	USNM 455153	♀	-	Autle	07-19-50	"	J.Marshall,Jr
" "	?						"
Thalasseus bergii	?						"
Anous stolidus	?						"

TABLE 15. Bird specimens collected from Arno Atoll (cont.)

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anous tenuirostris	USNM 455152	♂	-	Autle	07-19-50	Skin	J.Marshall,Jr
" "	?						"
" "	?						"
" "	?						"
" "	?						"
" "	?						"
" "	?						"
Gygis alba	?						"
Ducula oceanica							"
ratakensis	YIZM	♂	A	Arno	09-11-31	Skin	H. Orii
" "	YIZM	♂	-	"	09-28-31	"	"
" "	YIZM	*♂	A	"	"	"	"
" "	YIZM	♂	A	"	"	"	"
" "	YIZM	♀	A	"	09-11-31	Lost	"
" "	YIZM	♀	-	"	09-28-31	Skin	"
" "	USNM 425202	♀	A	Ine	07-04-50	"	J.Marshall,Jr
" "	USNM 425203	♂	A	"	"	"	"
Urodynamis taitensis	USNM 455151	♂	-	"	06-29-50	"	"

* denotes type specimen


MILI
0
1
2
3
4
STATUTE MILES
171°45'00"E
171°50'00"
171°55'00"
172°00'00"
172°05'00"
06°15'00"N
06°10'00"
06°05'00"
06°00'00"
Alu
Autle
Bikoro
Etwa
Dobwakwitkan
Jitni
Anil
Takowa
Burrh
Bwokwanalejwa
Anidoik
Bwokwadebto
Jabenor
Enalik
Enkor
Eden
Kirinagen
Nalab
Ajjelaran
Laarbab
Bue
Merige
Namo
Ennanlik
Nakaneej
Ajkadkadebwokwbwokw
Attongtonganebwokwbwokw
Ajwaan
Bworokulik
Bwokwanaelok
Garu
Madagai
Mili
Arbar
Tuwaaken
Jbein
Kinnatkan
Dobweoen
Waitojaiing
Enajet
Anewa
Lukunor
Jabwjabwon
Buruon
Bwokwankeear
Majenbwu
Nara
Wau
Ajeeang
Namake
Anemaro
Jaltuiej
Bwokwanlerro
Automw
Aneal
Anedoul
Bwokwajenmoon
Lejkibwa
Bwokwarobbwon
Akadiken
Chirubon

MILI ATOLL

Location: 06°08' N x 171°55' E.

Size and Shape: Irregular rectangle-shaped; Tip to tip (east-west) - 23 miles; Widest point (north-south) - 13 miles; Total lagoon area - 294.70 square miles; Total dry land - 6.15 square miles; Number of islands - 102; Height - 5 to 13 feet (Freeman, 1951; U.S. Navy, 1964).

Soil: No available data.

Vegetation: Four species known; most islands covered with Cocos and other trees, including Artocarpus, Carica, Ipomoea, and Musa (U.S. Navy, 1964).

Climate: Very wet, about 120-160 inches of rainfall yearly; Mean air temperature-82° F.; Wind - prevailing from east (Fosberg, 1956; U.S. Navy, 1964).

Human Population: Past - inhabited, 700 in 1881 (Findlay, 1886); 270 in 1948 (Freeman, 1951); Present - inhabited, 602 in 1964 (U.S. Department of State, 1965).

Scientific Visits: W. H. Hatheway - September 1952; U.S. Peace Corps (M. J. Trevor) - 1966-1968.

Avifauna: Twenty-two bird species have been recorded from Mili Atoll. These include 14 seabird species, 5 shorebird species, 1 heron, 1 cuckoo, and 1 domestic fowl. Four of the species are known to breed on the atoll, although 7 other species are potential breeders.

The following checklist presents the known bird species from Mili Atoll. This checklist was compiled from the following sources: (1) Baker, 1951; (2) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (3) Finsch, (a) 1880c, (b) 1884 , (c) 1893; (4) Yale Cross-cultural Survey, 1943; (5) Wiglesworth, 1891; (6) YIZM collection; and (7) Michael N. Trevor, pers. corresp., April 1968. These sources are referred to in the checklist by corresponding numbers and letters. Those 14 species marked by a single asterisk are new species records for Mili Atoll; the 4 species marked by double asterisks are new breeding records.

Mili Atoll Avifauna Checklist

Species	Status	Source
1) Pterodroma externa*	Accidental	7
2) Puffinus nativitatus*	Accidental	7
3) Phaethon rubricauda*	Visitor (possible breeder)	7
4) Sula sula* *	Resident breeder, winter, spring	7
5) Sula leucogaster* *	Resident breeder, winter spring	7

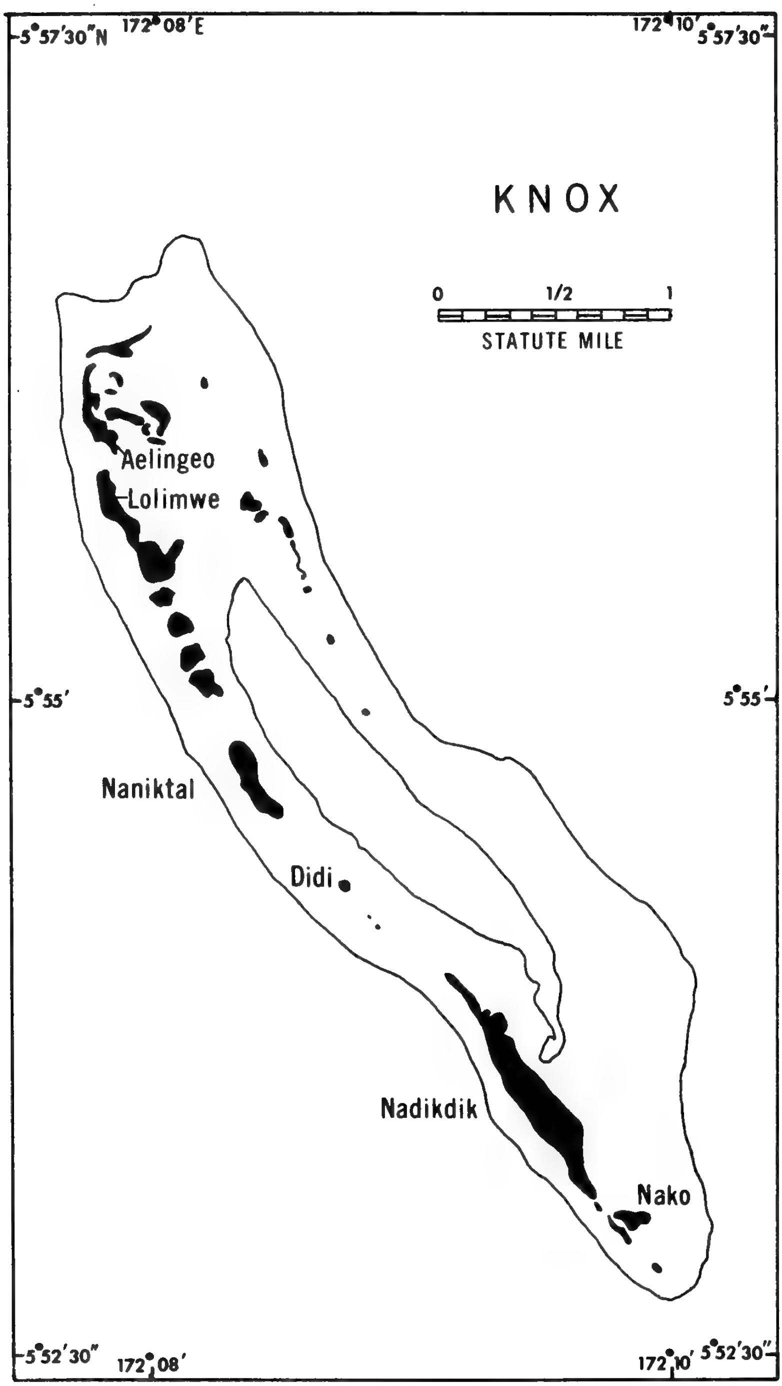
Species		Status	Source
6)	Fregata minor**	Resident breeder, winter spring	7
7)	Fregata ariel*	Visitor (March 28, 1968 ♂)	7
8)	Egretta sacra**	Resident breeder	7
9)	Gallus gallus	Introduced breeder ?	3c, 4
10)	Pluvialis dominica	Migrant	1, 2ab, 3b, 6
11)	Numenius phaeopus*	Migrant	7
12)	Numenius tahitiensis*	Migrant	7
13)	Heteroscelus incanum	Migrant	1,2ab, 3a, 5, 6
14)	Arenaria interpres	Migrant	1, 2ab, 6
15)	Sterna sumatrana*	Resident breeder ? common (spring)	7
16)	Sterna lunata*	Visitor++	7
17)	Sterna fuscata*	Visitor+	7
18)	Thalasseus bergii	Resident breeder ?	1, 2ab, 5
19)	Anous stolidus	Resident breeder ?	1, 2ab, 5
20)	Anous tenuirostris	Resident breeder ?	1, 2ab, 5
21)	Gygis alba	Resident breeder ?	1, 2ab, 5
22)	Urodynamis taitensis*	Migrant	7

+occasional at night.
++one night record 29 March 1968.

Bird specimens collected from Mili Atoll include 15 specimens of 7 species. These are all located in the Yamashina Institute of Zoology and Ornithology Museum in Tokyo, Japan.

TABLE 16. Bird specimens collected from Mili Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Pluvialis dominica	YIZM	♂	Juv	Mili I	09-10-31	Skin	H. Orii
" "	YIZM	♂	"	"	"	"	"
" "	YIZM	♀	"	"	"	"	"
Heteroscelus incanum	YIZM	♂	A	"	"	Lost	"
" "	YIZM	♀	A	"	"	"	"
" "	YIZM	♀	-	"	"	Skin	"
Arenaria interpres	YIZM	♀	A	"	"	"	"
" "	YIZM	♀	-	"	"	Lost	"
Thalasseus bergii	YIZM	♂	-	"	"	Skin	"
" "	YIZM	♂	-	"	"	"	"
Anous stolidus	YIZM	♂	A	"	"	"	"
" "	YIZM	♂	A	"	"	"	"
Anous tenuirostris	YIZM	♀	A	"	"	"	"
Gygis alba	YIZM	♂	A	"	"	"	"
" "	YIZM	♀	A	"	"	"	"


5°57'30"N
172°08'E
172°10'
5°57'30"
KNOX
0
1/2
1
STATUTE MILE
Aelingeo
Lolimwe
5°55'
5°55'
Naniktal
Didi
Nadikdik
Nako
5°52'30"
172°08'
172°10'
5°52'30"

KNOX ATOLL

Location: 05°55' N x 172°09' E.

Shape and Size: Irregular cigar-shaped; Tip to tip (north-south) - 4 miles; Widest point - 0.75 mile; Total lagoon area - 1.32 square miles; Total dry land area - 0.38 square miles; Number of islands - 10; Height - 49 feet (Freeman, 1951; U.S. Navy, 1964).

Soil: No available data.

Vegetation: One species known; eastern islands covered with sparse vegetation; western islands covered with *Cocos* and dense vegetation (U.S. Navy, 1964).

Climate: Very wet, about 160 inches of rainfall yearly; Mean air temperature-82° F.; Wind - prevailing from east (Fosberg, 1956; U.S. Navy, 1964).

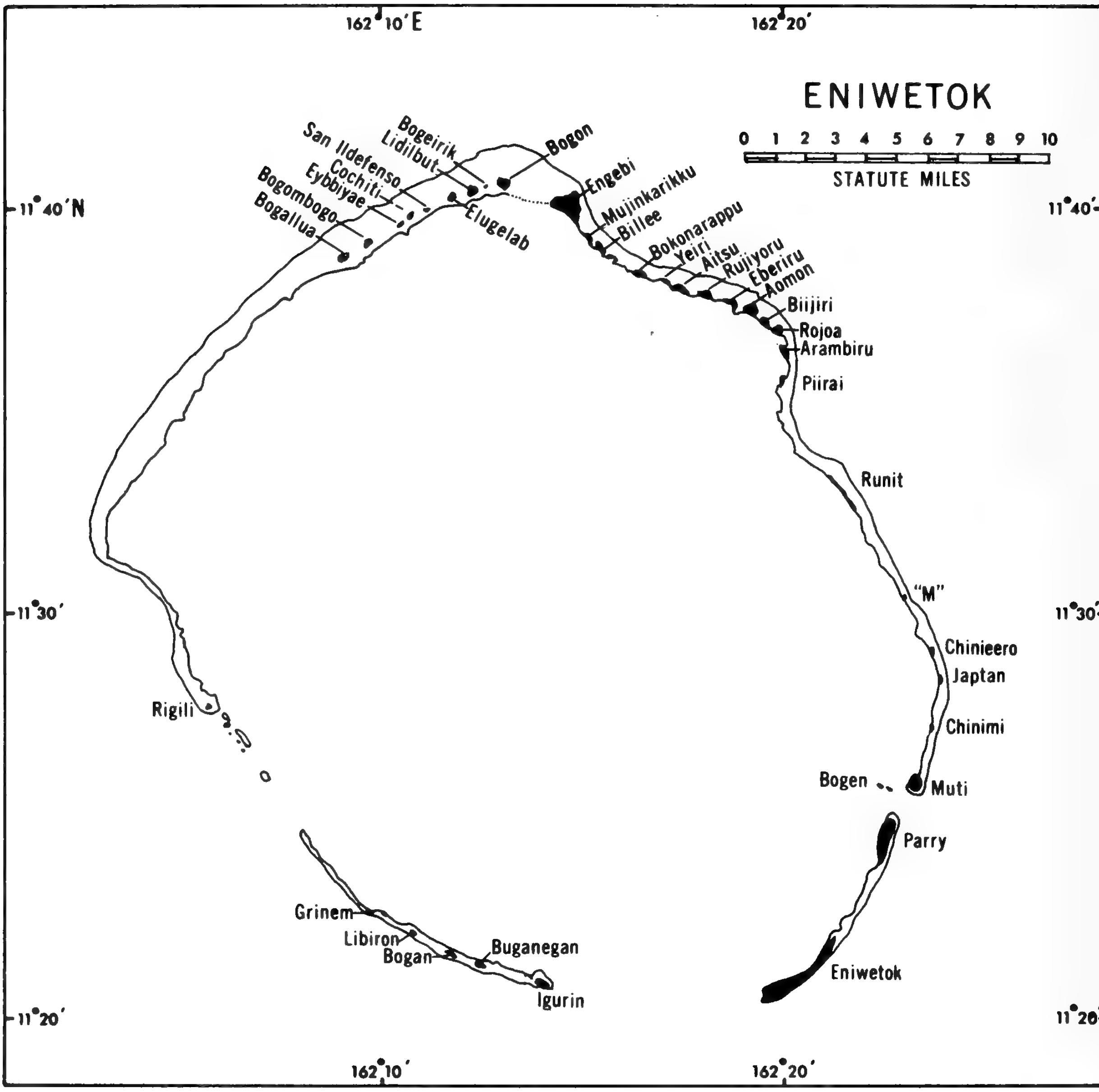
Human Population: Past - probably occasionally inhabited; Present - not inhabited, but occasionally visited by residents of Mili Atoll for harvesting copra.

Scientific Visits: None.

Avifauna: Only the Sooty Tern, *Sterna fuscata* (a sight record by Michael Trevor, pers. corresp., April 1968), has been recorded from Knox Atoll. Due to the closeness of Knox Atoll to Mili Atoll (2.1 nautical miles), 19 other species (breeders, migrants, and visitors) recorded on Mili Atoll probably also occur on Knox Atoll.

M A R S H A L L   I S L A N D S

R A L I K   C H A I N


ENIWETOK
0 1 2 3 4 5 6 7 8 9 10
STATUTE MILES
162°10′E
162°20′
11°40′N
11°40′
11°30′
11°30′
11°20′
11°20′
162°10′
162°20′
Bogeirik
Lidilbut
San Ildefenso
Cochiti
Eybbiyae
Bogombogo
Bogallua
Elugelab
Bogon
Engebi
Mujinkarikku
Billee
Bokonarappu
Yeiri
Aitsu
Rujiyoru
Eberiru
Aomon
Biijiri
Rojoa
Arambiru
Piirai
Runit
"M"
Chinieero
Japtan
Chinimi
Bogen
Muti
Parry
Eniwetok
Rigili
Grinem
Libiron
Bogan
Buganegan
Igurin

ENIWETOK ATOLL

Location: 11°30' N x 162°15' E.

Shape and Size: Irregular oval-shaped; Tip to tip (northwest-southeast) - 25 miles; Width - 20 miles; Total lagoon area - 395.34 square miles; Total dry land area - 2.47 square miles; Number of islands - 43; Height - 13 feet (Fosberg, 1956; Doran, 1959).

Soil: Beach (outer) - coral rock or gravel; Beach (inner) - coral sand; Interior - mostly sandy (Woodbury, 1962).

Vegetation: Ninety-five species; larger islands, varies from bare sand to dense jungle; smaller islands, *Scaevola* and *Messerschmidia* (Fosberg, 1956; Doran, 1959; Woodbury, 1962).

Climate: Moderate rainfall, about 60-70 inches yearly; Mean air temperature - 82° F.; Winds - prevailing from east to west (Fosberg, 1956).

Human Population: Past - inhabited, 30-40 in 1800's (Findlay, 1886); natives moved in 1947 for atomic tests, used by test personnel after 1947; Present - no natives inhabit the atoll, only military and civilian personnel.

Scientific Visits: Atomic Energy Commission (J.P.E. Morrison) 22 May - 7 June 1946; (A.B. Joseph) August 1964; University of Utah (A.M. Woodbury) February-May 1962; Bowling Green State University - 1964 to 1967; POBSP - 21 - 22 June 1966.

Avifauna: Thirty-two bird species are known from Eniwetok Atoll. These include 17 seabirds, 12 shorebirds, 1 heron, 1 domestic fowl, and 1 cuckoo. Fifteen species are potential breeders; however, only 9 species are known breeders.

Dayle Husted, of the POBSP, visited Eniwetok Atoll on 21 (arrived 0700) and 22 (departed 1000) June 1966 while aboard the U.S. Coast Guard Cutter *Basswood*. Observations were limited to the lagoon area. Brown Noddies, Black Noddies, White Terns, four Crested Terns, and a few light-phase Wedge-tailed Shearwaters were seen during the day. Two Golden Plovers flew across the lagoon just before sunset on the 21st. After dark, several Black-naped Terns, two of which were seen, were heard over the lagoon. Since these POBSP data are few, the normal annotated species accounts will be omitted.

The following checklist presents the recorded bird species from Eniwetok Atoll. This list was compiled from: (1) POBSP field data, 1966; (2) Woodbury, 1962; (3) Pearson and Knudsen, 1967; (4) Carpenter, Jackson, and Fall, in prep.; (5) Baker, 1951; (6) Arnold Joseph, pers. corresp., September 1964; (7) Gleize and Genelly, 1945; (8) Richardson, unpublished Ms; (9) Yale Cross-Cultural Survey, 1943, (10) USNM collection; (11) UUZM collection; and (12) BGSU collection. These sources are referred to in the checklist by the corresponding numbers and letters.

Eniwetok Atoll Avifauna Checklist

Species		Status	Source
1)	Puffinus pacificus	Accidental ?	1, 2, 3, 4, 11, 12
2)	Puffinus griseus	Accidental	3
3)	Puffinus tenuirostris	Accidental	3
4)	Phaethon rubricauda	Resident breeder, March, April, July-September; few	2, 3, 4
5)	Phaethon lepturus	Resident breeder, April; few	2, 3, 4, 12
6)	Sula sula	Resident breeder ?; few	5, 10
7)	Sula leucogaster	Resident breeder ?; few to 300	2, 3, 4, 5, 10, 12
8)	Fregata minor	Resident breeder ?; few to 300	2, 3, 4
9)	Egretta sacra	Resident breeder, June, July; common	2, 3, 4, 5, 6, 7, 10, 11
10)	Gallus gallus	Introduced breeder ?	9
11)	Pluvialis dominica	Migrant	1, 2, 3, 4, 10, 11, 12
12)	Squatarola squatarola	Migrant	3, 5, 7
13)	Charadrius dubius	Migrant	3, 5, 7
14)	Numenius phaeopus	Migrant	2, 3
15)	Numenius tahitiensis	Migrant	2, 3, 4, 6, 12
16)	Limosa lapponica	Migrant	3, 4, 12
17)	Heteroscelus brevipes	Migrant	3, 4, 10
18)	Heteroscelus incanum	Migrant	2, 3, 4, 10, 11
19)	Arenaria interpres	Migrant	2, 3, 4, 6, 10, 11, 12
20)	Crocethia alba	Migrant	2, 3
21)	Erolia acuminata	Migrant	2, 3, 11
22)	Tryngites subruficollis	Accidental	3
23)	Sterna paradisaea	Accidental	2
24)	Sterna sumatrana	Resident breeder, March-May; 300	1, 2, 3, 4, 10, 11, 12
25)	Sterna lunata	Resident breeder ?; few	2, 11
26)	Sterna fuscata	Resident breeder, March-May; July-Sept; few to 16,000+	2, 3, 4, 8, 10, 12
27)	Thalasseus bergii	Resident breeder, March ?	1, 2, 3, 4, 12
28)	Procelsterna cerulea	Resident breeder ?	2, 3,
29)	Anous stolidus	Resident breeder, Feb-May, summer; 1,000's	1, 2, 3, 4, 10, 11, 12
30)	Anous tenuirostris	Resident breeder, Feb.-May summer; 1,000's	1, 2, 3, 4, 10, 11, 12
31)	Gygis alba	Resident breeder, Feb.-May; 1,000's	1, 2, 3, 4, 5, 6, 10, 11, 12
32)	Urodynamis taitensis	Migrant	2

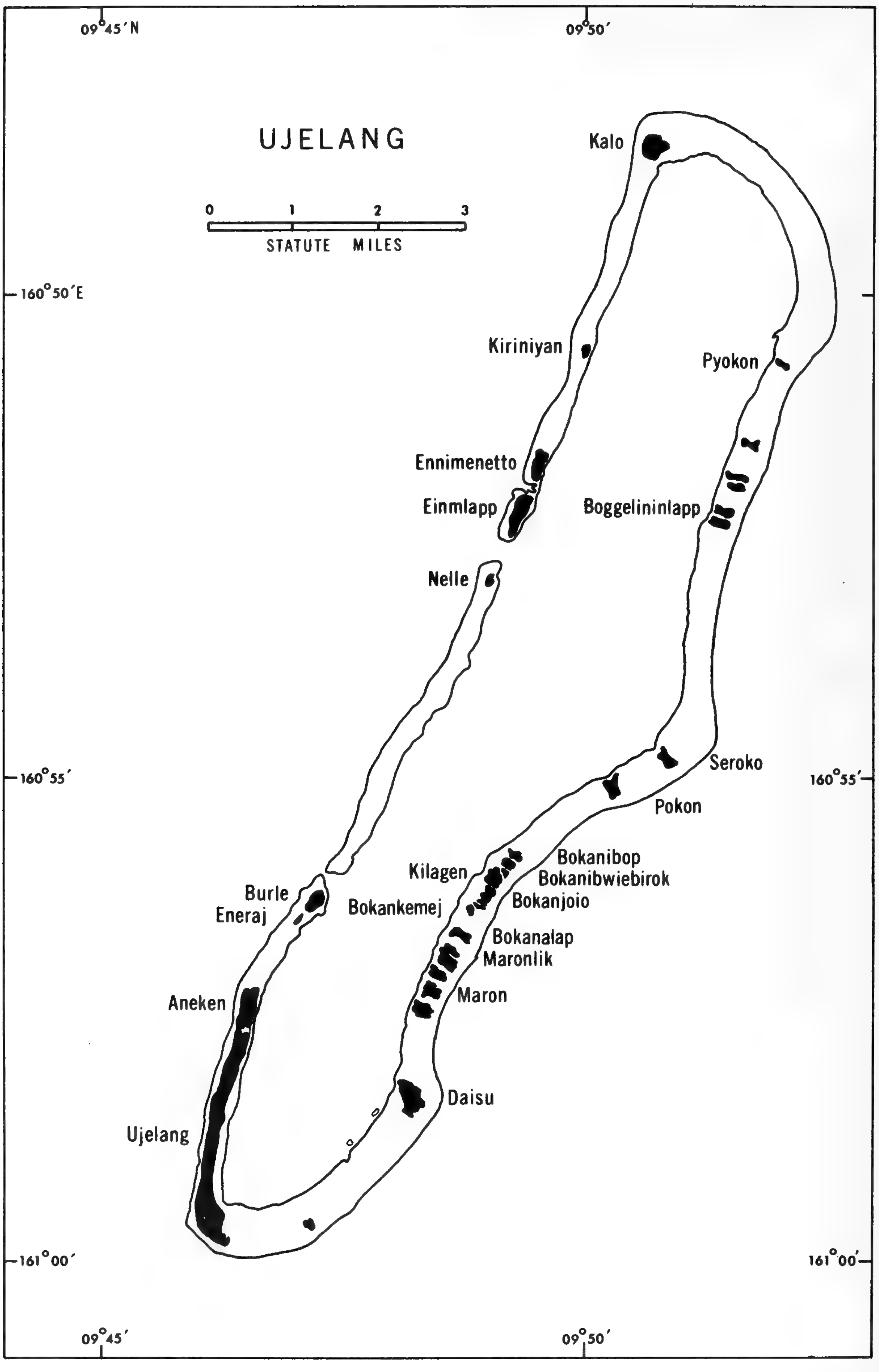
Bird specimens collected at Eniwetok Atoll include 57 specimens of 21 species as listed in Table 17. These are located in four museums.

TABLE 17. Bird specimens collected from Eniwetok Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Puffinus pacificus	UUZM 19922	♂	A	Chinimi	05-03-62	Skin	J. Bushman
" "	MLC 289						
" "	MLC 290						
Phaethon lepturus	MLC 195			Igurin	-64	Skin	
Sula sula	USNM 346997	?	?	Rigili	05-26-46	Skel.	J. Morrison
Sula leucogaster	BGSU 1151					Skin	
Fregata minor	UUZM 19794	♂	A	Parry	05-15-62	"	J.B.Bushman
Egretta sacra	USNM 388813	♂	A	Mui	05-28-46	"	J.Morrison
" "	UUZM 19792	♂	A	Japtan	05-09-62	"	J.B.Bushman'
" "	UUZM 19793	♂	A	Parry	04-28-62	"	"
Pluvialis dominica	USNM 388804	♂	I	Grinem	05-29-46	"	J.Morrison
" "	UUZM 19785	♂	A	Engebi	05-20-62	"	J.B.Bushman
" "	MLC 194						
" "	MLC 196						
Numenius tahitiensis	BGSU 1153						
Limosa lapponica	BGSU 1154						
Heteroscelus brevipes	USNM 388802	♂	A	Igurin	05-22-46	Skin	J.Morrison
Heteroscelus incanum	USNM 388803	♀	A	Rigili	05-25-46	"	"
" "	UUZM 19784	♀	A	Eniwetok I	05-17-62	"	J.B.Bushman
Arenaria interpres	USNM 388785	♀	A	Lidilbut	06-01-46	"	J.Morrison
" "	USNM 388786	♂	A	"	06--1-46	"	"
" "	USNM 388787	♂	A	"	"	"	"
" "	UUZM 19786	♂	A	Parry	05-15-62	"	J.B.Bushman
" "	BGSU 1152						
Erolia acuminata	UUZM 19795	♀	A	Eniwetok	05-16-62	Skin	J.B.Bushman
Tryngites subruficollis	USNM 487491	♀	A	"	04-06-65	"	J.W.Knudsen
Sterna sumatrana	USNM 388762	♀	A	Rigili	05-26-46	"	J.Morrison
" "	USNM 388764	♂	A	"	05-25-46	"	"
" "	USNM 388763	♀	A	Rujiyoru	06-02-46	"	"
" "	USNM 388765	♂	A	"	"	"	"
" "	USNM 388766	♂	A	"	"	"	"
" "	UUZM 19921	♀	A	Mujinkarikku	05-20-62	"	J.B.Bushman
" "	MLC 193						
" "	MLC 288						
Sterna lunata	UUZM 19791	♀	A	Eniwetok I	03-08-62	Skin	J.B.Bushman
Sterna fuscata	USNM 388754	♂	A	Grinem	05-29-46	"	J.Morrison
" "	MLC 196						
" "	MLC 286						
" "	MLC 287						
Thalasseus bergii	BGSU 1158						
Anous stolidus	USNM 388769	♀	A	Buganegan	05-26-46	Skin	J.Morrison
" "	USNM 388767	♂	I	Igurin	06-05-46	"	"
" "	USNM 388768	♀	A	"	05-22- 6	"	"
" "	USNM 388770	♂	I	"	"	"	"
" "	UUZM 19788	♂	A	Japtan	05-18-62	"	J.B.Bushman
" "	BGSU 1155						

TABLE 17. Bird specimens collected from Eniwetok Atoll (cont'd)

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anous tenuirostris	USNM 388794	♀	I?	Buganegan	05-28-46	Skin	J.Morrison
" "	USNM 388795	♂	A	"	"	"	"
" "	USNM 388796	♂	A	"	"	"	"
" "	UUZM 19787	♂	A	Japtan	05-18-62	"	J.B.Bushman
" "	UUZM 19789	♂	A	"	"	"	"
" "	BGSU 1156						
Gygis alba	USNM 388746	♂	A	Igurin	06-06-46	Skin	J.Morrison
" "	USNM 388749	♀	A	"	"	"	"
" "	USNM 388748	♀	A	Rigili	05-26-46	"	"
" "	UUZM 19790	♂	A	Uriah (sic)	05-15-62	"	J.B.Bushman
" "	BGSU 1157						



UJELANG
0 1 2 3
STATUTE MILES
09°45′N
09°50′
160°50′E
160°55′
160°55′
161°00′
161°00′
09°45′
09°50′
Kalo
Kiriniyan
Pyokon
Ennimenetto
Einmlapp
Boggelininlapp
Nelle
Seroko
Pokon
Bokanibop
Bokanibwiebirok
Kilagen
Burle
Eneraj
Bokankemej
Bokanjoio
Bokanalap
Maronlik
Maron
Aneken
Daisu
Ujelang

UJELANG ATOLL

Location: 09°49' N x 160°55' E.

Shape and Size: Long narrow elliptical-shaped; Tip to tip (northwest-southeast) - 14 miles; Width - 2 to 3.5 miles; Total lagoon area - 36.32 square miles; Total dry land area - 0.62 square miles; Number of islands - 35; Height - ? feet (Fosberg, 1956).

Soil: Rocky and sandy.

Vegetation: Forty-six species; larger islands, mostly *Cocos*; smaller islands, dry with grassy and wooded areas (Fosberg, 1956).

Climate: Moderately wet, about 70-100 inches of rainfall yearly; Mean air temperature - 82° F.; Winds - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 1,000 in 1800's (Findlay, 1886); 142 in 1948 (Freeman, 1951); Present - inhabited, 312 in 1964 (U.S. Department of State, 1965).

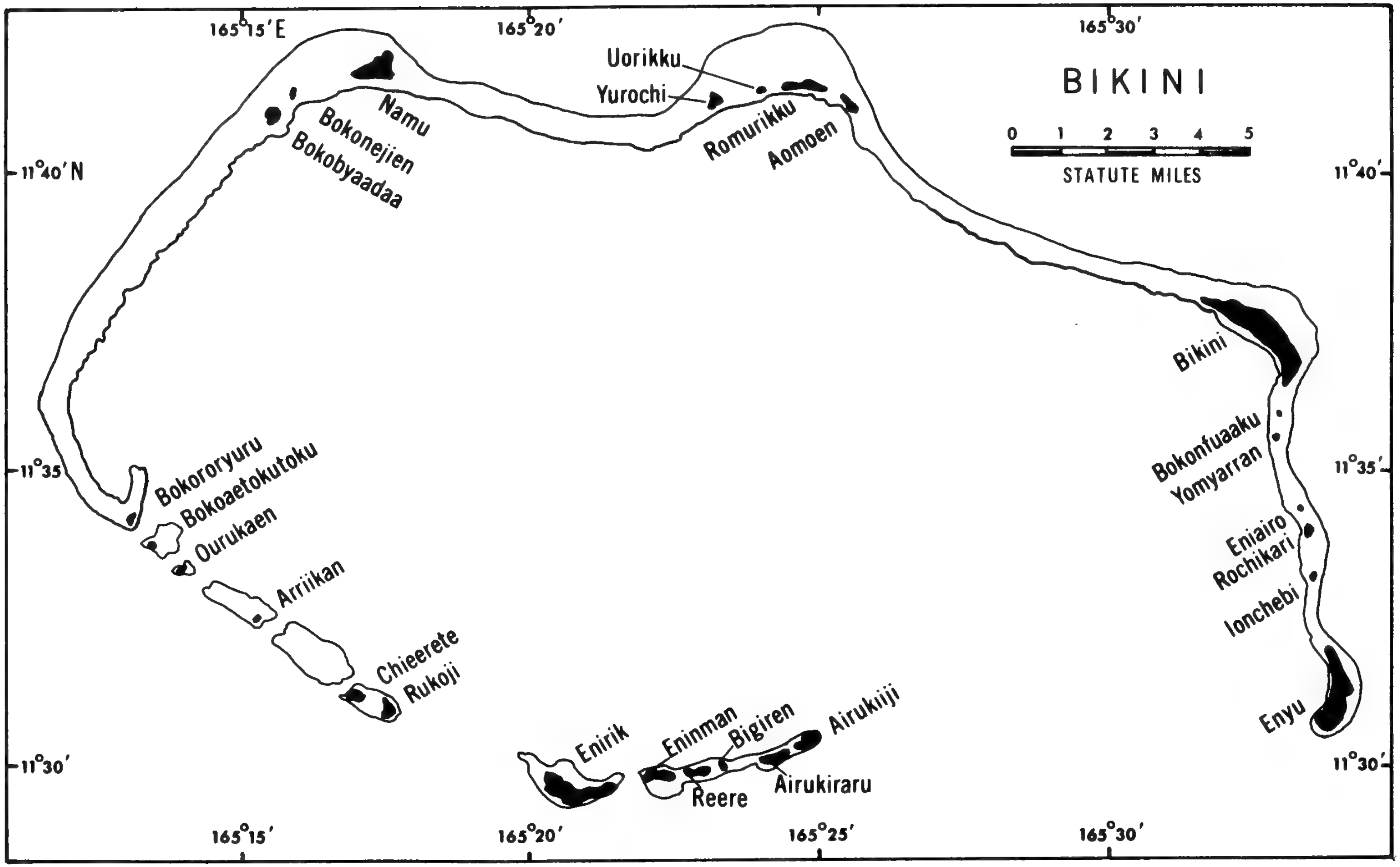
Scientific Visits: U.S. Geological Survey Expedition (F. R. Fosberg) - 3-8 February 1952.

Avifauna: Fourteen species of birds are known from Ujelang Atoll. Of these species, 7 are seabirds, 4 are shorebirds, 1 is a heron, 1 is a domestic fowl, and 1 a domestic duck. Three species are known to breed on the atoll, however, 10 species are potential breeders. No museum specimens exist from the atoll.

Fosberg (1966) observed the following species from Ujelang Atoll:

1)	*Fregata minor*#	Resident breeder ?
2)	*Egretta sacra*	Resident breeder ?
3)	*Cairina moschata*	Introduced breeder ?
4)	*Gallus gallus*	Introduced breeder ?
5)	*Pluvialis dominica*	Migrant
6)	*Numenius tahitiensis*	Migrant
7)	*Heteroscelus incanum*	Migrant
8)	*Arenaria interpres*	Migrant
9)	*Sterna sumatrana*	Resident breeder ?
10)	*Sterna fuscata*	Resident breeder, February (eggs)
11)	*Thalasseus bergii*	Resident breeder ?
12)	*Anous stolidus*	Resident breeder, February (eggs to young)
13)	*Anous tenuirostris*	Resident breeder, February eggs to large young)
14)	*Gygis alba*	Resident breeder ?

also known from a POBSP band recovery record.



BIKINI
0 1 2 3 4 5
STATUTE MILES
165°15'E
165°20'
165°30'
11°40'N
11°35
11°30'
11°40'
11°35'
11°30'
165°15'
165°20'
165°25'
165°30'
Namu
Bokonejien
Bokobyaadaa
Uorikku
Yurochi
Romurikku
Aomoen
Bikini
Bokonfuaaku
Yomyarran
Eniairo
Rochikari
Ionchebi
Enyu
Bokororyuru
Bokoaetokutoku
Ourukaen
Arriikan
Chieerete
Rukoji
Enirik
Eninman
Bigiren
Reere
Airukiiji
Airukiraru

BIKINI ATOLL

Location: 11°35' N x 165°23' E.

Shape and Size: Irregular ellipse-shaped; Tip to tip (east-west) - 26 miles; Width - 15 miles; Total lagoon area - 266.97 square miles; Total dry land area - 2.82 square miles; Number of islands - 29; Height - 10-19 feet (Fosberg, 1956; Doran, 1959).

Soil: Larger islands - sand, generally fine grained, horizontally bedded, some gravel interior; Small islands, mostly beach rock (Doran, 1959).

Vegetation: Species number unknown; large islands with *Cocos*; small islands wooded, few *Cocos*. Radioactive tests reduced much vegetation, but vegetation has returned (Fosberg, 1956; Doran, 1959).

Climate: Moderate rainfall, about 60-70 inches yearly; Mean air temperature - 82° F.; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 30 in 1800's (Findlay, 1886); 160+ before 1946, all natives removed in 1946 for atomic tests, up to 3,000 personnel for tests (Freeman, 1951); Present - No natives inhabit the atoll.

Scientific Visits: Japanese visit (S. Kawakami) 3 January 1933; Atomic Energy Commission - February-August 1946, July-August 1947, (A. B. Joseph) August 1964.

Avifauna: Seventeen bird species are known from Bikini Atoll. These include 10 seabirds, 4 shorebirds, 1 heron, 1 rail, and 1 cuckoo. Five species are known breeders on Bikini Atoll, while 6 other species are potential breeders.

The following checklist records the known bird species from Bikini Atoll, as well as presents the status and source for each species and record. The sources from which this list was compiled include: (1) Baker, 1951; (2) Arnold Joseph, pers. corresp., September 1964; (3) Traylor, pers. corresp., September 1965; (4) Mayr, 1945; (5) Yamashina, 1940; (6) Hand-list of Japanese Birds, 1942; (7) USNM collection; (8) CNHM collection; and (9) YIZM collection. These sources are referred to in the checklist by the corresponding numbers and letters. The three species marked with an asterisk are heretofore unpublished specimen records for Bikini Atoll.

Bikini Atoll Avifauna Checklist

Species	Status	Source
1) Puffinus pacificus*	Resident breeder ?	7
2) Sula sula	Resident breeder, May	1, 2, 3, 7, 8
3) Sula leucogaster*	Resident breeder ?	7
4) Fregata minor	Resident breeder ?	1, 2, 7
5) Egretta sacra	Resident breeder ?	1, 2, 7
6) Poliolimnas cinereus micronesiae	Accidental	1, 4, 5, 6, 9
7) Pluvialis dominica	Migrant	1, 7
8) Numenius tahitiensis	Migrant	1, 2, 7
9) Heteroscelus incanum	Migrant	1, 7
10) Arenaria interpres	Migrant	1, 2, 7
11) Sterna sumatrana	Resident breeder ?	1, 2, 7
12) Sterna fuscata*	Resident breeder ?	7
13) Thalasseus bergii	Resident breeder, August	1, 2, 7
14) Anous stolidus	Resident breeder, March	1, 2, 3, 7, 8
15) Anous tenuirostris	Resident breeder, July	1, 2, 3, 7, 8
16) Gygis alba	Resident breeder, March	1, 2, 3, 7, 8
17) Urodynamis taitensis	Migrant	1, 7

Bird specimens collected at Bikini Atoll include 126 specimens of 17 species, as listed in Table 18.

TABLE 18. Bird specimens collected from Bikini Atoll.

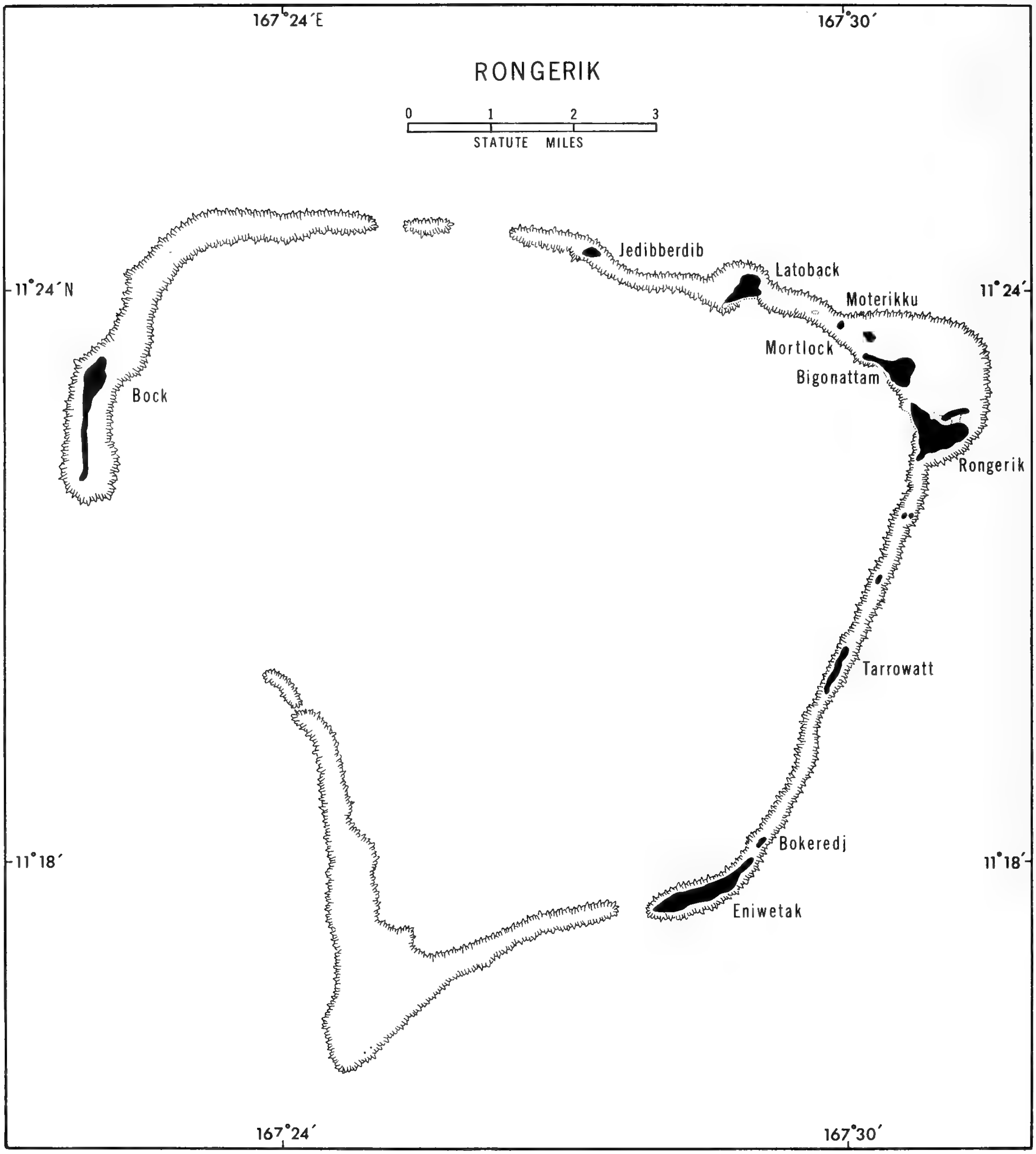
Species	Museum	Age	Sex	Location	Date	Status	Collector
Puffinus pacificus	USNM 347274	?	?	Bikini I	08-03-47	Skel.	Morrison
Sula sula	USNM 386637	♂	SA	Ourukaen	05-01-46	Skin	"
" "	USNM 386638	♀	A	"	05-02-46	"	"
" "	USNM 386639	♀	A	"	"	"	"
" "	USNM 386640	♀	A	"	"	"	"
" "	USNM 386641	♀	SA	"	05-01-46	"	"
" "	USNM 386643	♀	I	"	05-02-46	"	"
" "	USNM 386644	♀	I	"	"	"	"
" "	USNM 386645	♂	A	"	"	"	"
" "	USNM 386646	♂	N	"	05-03-46	"	"
" "	USNM 388728	♀	N	"	07-08-46	"	"
" "	USNM 388811	♀	I	"	"	"	"
" "	USNM 386642	♀	I	*Bokororyuru	04-28-46	"	"
" "	USNM 399718	♀	A	*"	07-29-46	"	"
" "	USNM 399719	♀	A	*"	"	"	"
" "	USNM 399720	♂	A	*"	"	"	"
" "	CNHM 153256	♂	A	--	06-14-46	"	Traylor
" "	CNHM 153257	♂?	A	--	05-25-46	"	"
" "	CNHM 153258	♀	I	--	"	"	"
" "	CNHM 153259	♀?	I	--	06-14-46	"	"
" "	CNHM 153260	♂	A	--	05-25-46	"	"
" "	CNHM 153261	♂	I	--	"	"	"
" "	CNHM 153262	♂	I	--	"	"	"
" "	CNHM 153263	♀	I	--	"	"	"
" "	CNHM 153264	♂	A	--	"	"	"
" "	CNHM 153265	♀	I	--	"	"	"
" "	CNHM 153266	♀	A	--	"	"	"
" "	CNHM 153267	♀	N	--	"	"	"
Sula leucogaster	USNM 399721	♂	A	*Bokororyuru	07-24-47	"	Morrison
" "	USNM 399722	♀	A	*"	07-29-47	"	"
" "	USNM 399723	♂	I	*"	07-24-47	"	"
" "	USNM 399724	♀	I	*"	"	"	"
Fregata minor	USNM 386627	♀	I	Bikini I	03-11-46	"	"
" "	USNM 386625	♀	I	Bokororyuru	04-29-46	"	"
" "	USNM 386628	♂	I	"	"	"	"
" "	USNM 386634	♀	SA	Yurochi	03-22-46	"	"
" "	USNM 386626	♀	I	Namu	03-29-46	"	"
" "	USNM 386629	♀	I	"	03-30-46	"	"
" "	USNM 386630	♀	I	"	04-13-46	"	"
" "	USNM 386631	♀	SA	"	03-30-46	"	"
" "	USNM 386632	♂	A	Ourukaen	05-03-46	"	"
" "	USNM 386633	♂	A	Arriikan	05-14-46	"	"
Egretta sacra	USNM 386635	♂	A	Namu	04-02-46	"	"
" "	USNM 386636	♀	A	"	03-29-46	"	"
Poliolimnas cinereus micronesiae	YIOM 27726	?	A	Bikini I	01-03-33	alc.	Kawakami

TABLE 18. Bird specimens collected from Bikini Atoll (contd.)

Species	Museum	Sex	Age	Location	Date	Status	Collector
Pluvialis dominica	USNM 386677	♀	A	Bikini I	03-04-46	Skin	Morrison
" "	USNM 386678	♂	A	"	03-07-46	"	"
" "	USNM 386679	♂	A	"	03-04-46	"	"
" "	USNM 386680	♂	A	"	05-03-46	"	"
Numenius tahitiensis	USNM 386670	♀	A	"	03-14-46	"	"
" "	USNM 386671	♂	A	"	03-10-46	"	"
" "	USNM 386672	♂	A	Namu	04-02-46	"	"
" "	USNM 386673	♀	A	Bokoaetokutoku	04-30-46	"	"
Heteroscelus incanum	USNM 386681	♀	?	Bokonfuaaku	02-28-46	"	"
" "	USNM 386682	♀	?	Bokororyuru	04-28-46	"	"
" "	USNM 386683	♀	?	Bikini I	02-26-46	"	"
Arenaria interpres	USNM 386674	♀	?	"	03-04-46	"	"
" "	USNM 386675	♂	?	"	"	"	"
" "	USNM 386676	♀	?	"	02-26-46	"	"
" "	USNM 399743	♂	?	Namu	08-07-47	"	"
" "	USNM 399744	♂	?	"	"	"	"
Sterna sumatrana	USNM 386660	♂	A	Bokororyuru	04-30-46	"	"
" "	USNM 386661	♂	A	"	"	"	"
" "	USNM 386662	♂	A	Bikini I	03-26-46	"	"
" "	USNM 386663	♀	A	"	"	"	"
" "	USNM 399737	♂	I	Namu	08-07-47	"	"
Sterna fuscata	USNM 388755	♀	A	Bikini I	07-08-46	"	"
" "	USNM 399732	♂	A	Reere	07-18-47	"	"
" "	USNM 399733	♀	A	"	"	"	"
Thalasseus bergii	USNM 386647	♂	A	Bikini I	03-12-46	"	"
" "	USNM 386648	♀	A	"	"	"	"
" "	USNM 396649	♂	I	"	03-11-46	"	"
" "	USNM 386650	♂	A	"	03-04-46	"	"
" "	USNM 399730	♂	N	"	08-26-47	"	"
" "	USNM 388729	♀	N	Bokobyaadaa	08-19-46	"	"
" "	USNM 388730	♂	N	"	"	"	"
" "	USNM 388731	♂	N	"	"	"	"
" "	USNM 388732	♀	N	"	"	"	"
" "	USNM 388734	♀	N	"	"	"	"
" "	USNM 388744	♂	A	"	"	"	"
" "	USNM 388745	♀	I	"	"	"	"
" "	USNM 399729	♂	A	Eninman	07-18-47	"	"
Anous stolidus	USNM 386651	♀	A	Bokonfuaaku	02-28-46	"	"
" "	USNM 386652	♂	A	"	"	"	"
" "	USNM 40730	-	-	Chieerete	03-19-46	Eggs	"
" "	USNM 346998	?	N	"	"	Alc.	"
" "	USNM 386654	♀	N	"	"	Skin	"
" "	USNM 386655	♂	N	"	"	"	"
" "	USNM 388775	♂	A	Airukiraru	07-07-46	"	"

TABLE 18. Bird specimens collected from Bikini Atoll (contd.)

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anous stolidus	USNM 388776	♀	A	Romurikku	08-05-46	Skin	Morrison
" "	CNHM 153290	♂	-	--	05-26-46	"	Traylor
" "	CNHM 153291	♂	-	--	"	"	"
" "	CNHM 153292	♀	-	--	"	"	"
" "	CNHM 153293	♀	-	--	"	"	"
" "	CNHM 153294	♀	-	--	"	"	"
" "	CNHM 153295	♂	I	--	"	"	"
" "	CNHM 153296	♂	-	--	"	"	"
" "	CNHM 153297	♀	-	--	"	"	"
" "	CNHM 153298	♂	-	--	03-11-46	"	"
" "	CNHM 153299	♀	N	--	04-06-46	"	"
Anous tenuirostris	USNM 386656	♂	A	Arriikan	05-14-46	"	Morrison
" "	USNM 386659	♂	A	"	"	"	"
" "	USNM 386657	♀	A	Ourukaen	05-02-46	"	"
" "	USNM 386658	♂	A	"	"	"	"
" "	USNM 388792	♀?	N	"	07-08-46	"	"
" "	USNM 388791	♂	A	Airukiraru	07-07-47	"	"
" "	USNM 388793	♂	A	Yurochi	07-13-46	"	"
" "	CNHM 153306	♀	-	--	05-26-46	"	Traylor
" "	CNHM 153307	♀	-	--	"	"	"
" "	CNHM 153308	♀	-	--	"	"	"
" "	CNHM 153309	♀	-	--	"	"	"
" "	CNHM 153310	♀	-	--	"	"	"
" "	CNHM 153311	♀	-	--	"	"	"
Gygis alba	USNM 386664	♂	N	Ionchebi	03-16-46	"	Morrison
" "	USNM 396669	♀	A	"	"	"	"
" "	USNM 386665	♂	I	Chieerete	03-19-46	"	"
" "	USNM 386666	♂	A	Bikini I	02-27-46	"	"
" "	USNM 386668	♀	A	"	"	"	"
" "	USNM 386667	♀	A	Romurikku	03-02-46	"	"
" "	USNM 388751	♀	A	Airukiraru	07-06-46	"	"
" "	USNM 388753	♂?	I	Ourukaen	08-12-46	"	"
" "	USNM 399736	♀	A	Eninman	07-19-46	"	"
" "	USNM 40728	-	-	Yurochi	03-22-46	2 eggs	"
" "	CNHM 153312	♀	-	--	03-11-46	Skin	Traylor
Urodynamis taitensis	USNM 386684	♀	A	Ourukaen	05-01-46	"	Morrison
" "	USNM 399741	♂	A	Namu	08-06-47	"	"


167°24'E
167°30'
RONGERIK
0
1
2
3
STATUTE MILES
11°24'N
11°24'
11°18'
11°18'
Jedibberdib
Latoback
Moterikku
Mortlock
Bigonattam
Bock
Rongerik
Tarrowatt
Bokeredj
Eniwetak
167°24'
167°30'

RONGERIK ATOLL

Location: 11°21' N x 167°26' E.

Shape and Size: Irregular triangular-shaped; Tip to base (northeast to southwest) - 36 miles; Width (southwest base) - 20 miles; Total lagoon area - 70.36 square miles; Total dry land area - 0.81 square miles; Number of islands - 16; Height - 28 feet (Fosberg, 1956).

Soil. No available data.

Vegetation: Number of species unknown; large islands, Pisonia and Cordia forests common, a few planted Cocos; small islands, scrub or low woodland (Fosberg, 1956, 1966).

Climate: Moderate rainfall, about 60-70 inches yearly; Mean air temperature - 82 F.; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, few (mostly nonpermanent) in 1800's, (Findlay, 1886); none in 1948 (Freeman, 1951); Present - uninhabited in 1964 (U.S. Department of State, 1965).

Scientific Visits: Atomic Energy Commission, May-July 1946, August 1947; U.S. Navy (F. R. Fosberg) - 11 February 1956.

Avifauna: Twelve bird species are known from Rongerik Atoll. Of these 12, 8 are seabirds and 4 are shorebirds. Two are known breeders, while 6 other species are considered to be potential breeders.

The following checklist records the known bird species from Rongerik Atoll. This list was compiled from the following sources: (1) Fosberg, 1966; (2) Traylor, pers. corresp., September 1965; (3) USNM collection; and (4) CNHM collection. These sources are referred to in the checklist by the corresponding numbers and letters. The three species marked with an asterisk are hereunto unpublished species records from Rongerik Atoll.

Rongerik Atoll Avifauna Checklist

Species	Status	Source
1) Puffinus pacificus*	Resident breeder ?	3
2) Fregata minor	Resident breeder ?	4
3) Pluvialis dominica	Migrant	2, 3, 4
4) Numenius tahitiensis	Migrant	1, 2, 3, 4
5) Heteroscelus incanum	Migrant	1
6) Arenaria interpres*	Migrant	3
7) Sterna sumatrana	Resident breeder ?	2, 4
8) Sterna fuscata*	Resident breeder ?	3
9) Thalasseus bergii	Resident breeder ?	2, 4
10) Anous stolidus	Resident breeder, March; few	1,2,3,4
11) Anous tenuirostris	Resident breeder ?	2, 3, 4
12) Gygis alba	Resident breeder, March, February, few	1, 2, 3, 4

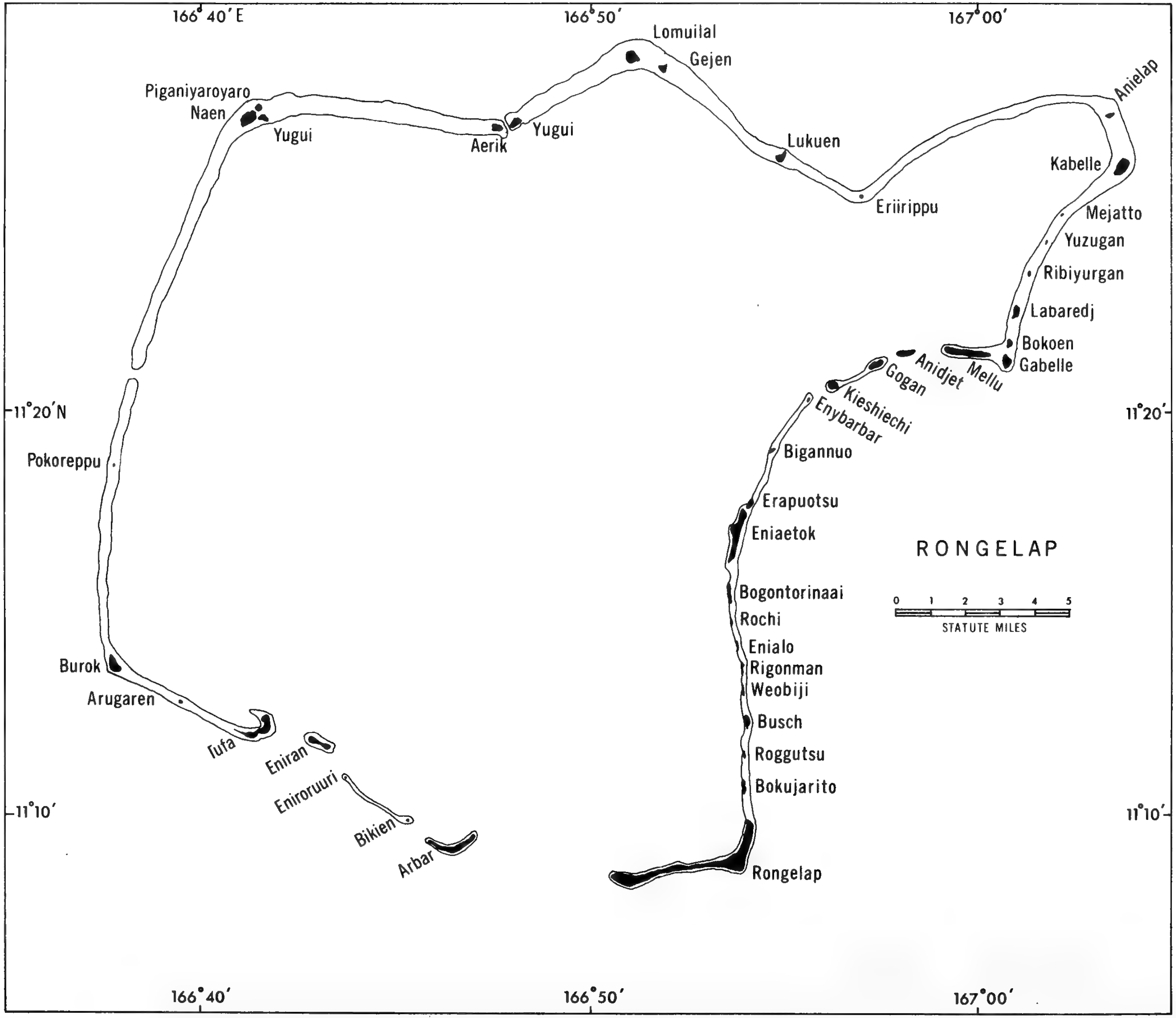
Bird specimens collected from Rongerik Atoll are listed in Table 19. These include 55 specimens of 11 species.

TABLE 19. Bird specimens collected from Rongerik Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Puffinus pacificus	USNM 347273	?	?	Latoback	08-15-47	Skel.	J.P.E.Morrison
Fregata minor	CNHM 153269	♀	I	--	06-03-46	Skin	M.A.Traylor,Jr.
" "	CNHM 153322	♀	A	--	06-04-46	"	"
" "	CNHM 153323	♂	I	--	06-03-46	"	"
" "	CNHM 153324	♀	A	--	05-14-46	"	"
" "	CNHM 153325	♀	I	--	06-04-46	"	"
" "	CNHM 153326	♀	A	--	06-03-46	"	"
" "	CNHM 153327	♀	A	--	05-14-46	"	"
Pluvialis dominica	USNM 399745	♂	?	Latoback	08-16-47	"	J.P.E.Morrison
" "	USNM 399746	♂	I	Bigonattam	08-22-47	"	"
" "	CNHM						
" "	CNHM						
Numenius tahitiensis	USNM 399738	♂	A	Bigonattam	08-21-47	Skin	J.P.E.Morrison
" "	USNM 399739	♂	A	"	08-22-47	"	"
" "	USNM 399740	♂	A	Mortlock	08-21-47	"	"
" "	CNHM 153274	♂	A	--	05-31-46	"	M.A.Traylor,Jr.
" "	CNHM						
" "	CNHM						
Arenaria interpres	USNM 388782	♀	?	Latoback	06-28-46	Skin	J.P.E.Morrison
" "	USNM 388783	♂	?	"	"	"	"
" "	USNM 388784	♂	I?	"	"	"	"
" "	USNM 399742	♀	?	Bigonattam	08-22-47	"	"
Sterna sumatrana	CNHM 153277	♀	?	--	05-12-46	"	M.A.Traylor, Jr.
" "	CNHM 153278	♂	?	--	"	"	"
" "	CNHM 153280	♂	?	--	05-31-46	"	"
" "	CNHM 153281	♂	?	--	05-12-46	"	"
" "	CNHM 153328	♂	N	--	07-19-46	"	"
" "	CNHM 153329	♀	N	--	"	"	"
Sterna fuscata	USNM 399731	♀	A	Latoback	08-15-47	"	J.P.E.Morrison
Thalasseus bergii	CNHM 153289	♂	?	--	05-12-46	"	M.A.Traylor,Jr.
Anous stolidus	USNM 388777	♀	A	Bock	06-27-46	"	J.P.E.Morrison
" "	USNM 388778	♀	I	"	"	"	"
" "	USNM 388779	♂	A	"	"	"	"
" "	USNM 388780	♀	A	"	"	"	"
" "	USNM 399726	♂	A	Latoback	08-16-47	"	"
" "	CNHM 153300	♀	I	--	05-12-46	"	M.A.Traylor,Jr.
" "	CNHM 153301	♀	?	--	"	"	"
" "	CNHM 153330	♂	N	--	07-19-46	"	"
" "	CNHM 153331	♀	N	--	"	"	"
Anous tenuirostris	USNM 388788	♂	A	Bock	06-27-46	"	J.P.E.Morrison
" "	USNM 388789	♀	A	"	"	"	"
" "	USNM 388790	♀	A	"	"	"	"
" "	USNM 399727	♂	A	"	08-19-47	"	"
" "	USNM 399728	♀	A	"	"	"	"

TABLE 19. Bird specimens collected from Rongerik Atoll (contd.).

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anous tenuirostris	CNHM 153302	♀	-	--	05-13-46	Skin	M.A.Traylor,Jr.
" "	CNHM 153303	♀	-	--	"	"	"
" "	CNHM 153304	♀	N	--	"	"	"
" "	CNHM 153305	♀	N	--	"	"	"
" "	CNHM 153332	♂	N	--	07-23-46	"	"
Gygis alba	USNM 388747	♀	A	Latoback	06-28-46	"	J.P.E.Morrison
" "	USNM 399734	♂	A	off Bock	08-13-47	"	"
" "	USNM 399735	♀	A	Mortlock	08-21-47	"	"
" "	CNHM 153319	♀	-	--	05-12-46	"	M.A.Traylor,Jr.
" "	CNHM 153320	♀	-	--	"	"	"
" "	CNHM 153321	♂	-	--	"	"	"



RONGELAP
0 1 2 3 4 5
STATUTE MILES
166° 40′ E
166° 50′
167° 00′
11° 20′ N
11° 10′
11° 20′
11° 10′
166° 40′
166° 50′
167° 00′
Piganiyaroyaro
Naen
Yugui
Aerik
Yugui
Lomuilal
Gejen
Lukuen
Eriirippu
Anielap
Kabelle
Mejatto
Yuzugan
Ribiyurgan
Labaredj
Bokoen
Gabelle
Mellu
Anidjet
Gogan
Kieshiechi
Enybarbar
Bigannuo
Erapuotsu
Eniaetok
Bogontorinaai
Rochi
Enialo
Rigonman
Weobiji
Busch
Roggutsu
Bokujarito
Rongelap
Pokoreppu
Burok
Arugaren
Iufa
Eniran
Eniroruuri
Bikien
Arbar

RONGELAP ATOLL

Location: 11°20' N x 166°50' E.

Shape and Size: Irregular diamond-shaped; Tip to tip (northeast-southwest) - 30 miles; Widest point (northwest-southeast) - 23 miles; Total lagoon area - 426.44 square miles; Total dry land area - 2.46 square miles; Number of islands - 58; Height - ? feet (Fosberg, 1956).

Soil: Not especially fertile (Fosberg, 1956).

Vegetation: Species number unknown; large islands, some Cocos, but much native brush and woodland; small islands, scrub-covered (Fosberg, 1956).

Climate: Moderate rainfall, about 60-70 inches yearly; Mean air temperature - 82° F., Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 120 in 1800's (Findlay, 1886); 95 in 1948 (Freeman, 1951); Present - inhabited, 228 in 1964 (U.S. Department of State, 1965).

Scientific Visits: C. H. Townsend - 18 January 1900; Atomic Energy Commission - May, June, July, August 1946, (A. B. Joseph), August 1964; U.S. Navy (F. R. Fosberg) - 7-9, 15 February 1956.

Avifauna: Fourteen bird species are known from Rongelap Atoll. Of these 14, 8 are seabirds, 4 are shorebirds, 1 is a heron, and 1 is a domestic fowl. Although 10 species are potential breeders, only 3 are known breeders.

The following checklist presents the recorded bird species from Rongelap Atoll. This list was compiled from the following sources: (1) Fosberg, 1966; (2) Traylor, pers. corresp., September 1965; (3) Hand-list of Japanese Birds (a) 1932, (b) 1942, (c) 1958; (4) Townsend and Wetmore, 1919; (5) Baker, 1951; (6) Momiyama, 1922; (7) Arnold Joseph, pers. corresp., September 1964; (8) USNM collection; (9) CNHM collection; (10) MCZ collection; and (11) Yale Cross-Cultural Survey, 1932. These sources are referred to in the checklist by the corresponding numbers and letters. The one species marked by an asterisk is hereunto an unpublished species record from this atoll.

Rongelap Atoll Avifauna Checklist

Species	Status	Source
1) *Puffinus pacificus*	Resident breeder ?	2, 9
2) *Sula sula**	Resident breeder ?	8
3) *Fregata minor*	Resident breeder ?	2, 8, 9?
4) *Egretta sacra*	Resident breeder ?	2, 7, 9

Species	Status	Source
5) Gallus gallus	Introduced breeder ?	1, 11
6) Pluvialis dominica	Migrant	1, 4, 5, 8, 10
7) Numenius tahitiensis	Migrant	1, 3b, 4, 5, 7, 8
8) Heteroscelus incanum	Migrant	1, 3b, 4, 5, 7, 8,
9) Arenaria interpres	Migrant	1, 2, 3, 4ab, 5, 6, 7, 8, 9
10) Sterna sumatrana	Resident breeder ?	2, 8, 9
11) Thalasseus bergii	Resident breeder ?	2, 8, 9
12) Anous stolidus	Resident breeder; February; few	1, 8
13) Anous tenuirostris	Resident breeder, February; few	1, 7, 8
14) Gygis alba	Resident breeder, May ?	1, 2, 7, 8, 9,

Bird specimens collected at Rongelap include 63 specimens of 12 species.

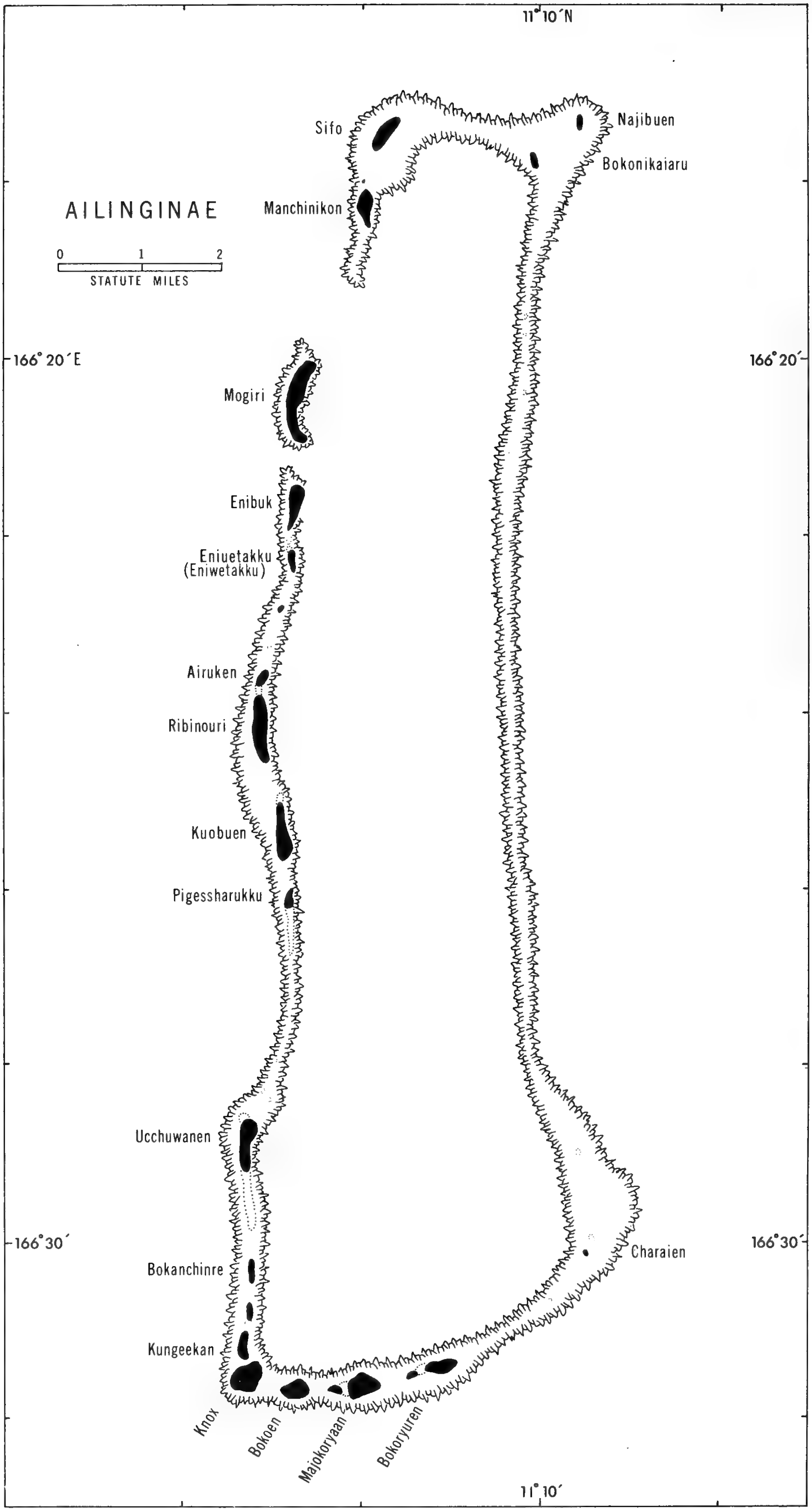
TABLE 20. Bird specimens collected from Rongelap Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Puffinus pacificus	CNHM 153456	♀	A	--	06-05-46	Skin	M.A.Traylor,Jr.
Sula sula	USNM 346996	?	?	Naen	07-30-46	Skel.	J.P.E.Morrison
Fregata minor	USNM 388812	♀?	I	"	"	Skin	"
" "	USNM 346995	?	?	"	"	Skel.	"
Egretta sacra	CNHM 153270	♂	A	--	05-18-46	Skin	"
Pluvialis dominica	MCZ 81921	♂	?	--	01-18-00	"	C.H.Townsend
" "	USNM 212228	♂	?	Rongelap I	"	"	"
" "	USNM 212229	♀	?	"	"	"	"
" "	USNM 388805	♀	?	"	06-21-46	"	J.P.E.Morrison
" "	USNM 388806	♀	?	"	"	"	"
" "	USNM 388807	♀	?	Burok	07-24-46	"	"
" "	USNM 388808	♀	?	?	"	"	"
Numenius tahitiensis	USNM 212201	♀	?	Rongelap I	01-18-00	"	C.H.Townsend
" "	USNM 212202	♂	?	"	"	"	"
" "	USNM 212203	♂	?	"	"	"	"
" "	USNM 212204	♀	?	"	"	"	"
" "	USNM 388809	♂	?	Lomuilal	08-01-46	"	J.P.E.Morrison
" "	USNM 388810	♂	?	"	"	"	"
Arenaria interpres	USNM 212214	♂	?	Rongelap I	01-18-00	"	C.H.Townsend
" "	USNM 212215	?	?	"	"	"	"
" "	USNM 388781	♀	?	Arbar	06-16-46	"	J.P.E.Morrison
" "	CNHM	♀	?				
Sterna sumatrana	CNHM 153279	♂	?	--	06-28-46	Skin	M.A.Traylor,Jr.
" "	CNHM 153282	♂	?	--	"	"	"
" "	CNHM 153283	♂	?	--	"	"	"
" "	CNHM 153284	♂	?	--	"	"	"
" "	USNM 388756	?	I	Lomuilal	08-01-46	"	J.P.E.Morrison
" "	USNM 388757	♀	I	Erapuotsu	07-20-46	"	"
" "	USNM 388760	♀	A	"	"	"	"
" "	USNM 388758	♂	A	Kabelle	06-20-46	"	"

TABLE 20. Bird specimens collected from Rongelap Atoll (contd.)

Species	Museum	Sex	Age	Location	Date	Status	Collector
Sterna sumatrana	USNM 388759	♀	A	Burok	07-24-46	Skin	J.P.E.Morrison
" "	USNM 388761	♂	A	Arbar	06-16-46	"	"
Thalasseus bergii	USNM 388733	♂?	N	Yugui	07-31-46	"	"
" "	USNM 388735	♂	A	"	"	"	"
" "	USNM 388736	♀	A	"	"	"	"
" "	USNM 388737	♂	A	"	"	"	"
" "	USNM 388738	♀	A	"	"	"	"
" "	USNM 388741	♂	A	"	"	"	"
" "	USNM 388742	♀	A	"	"	"	"
" "	USNM 388739	♀	A	Eniaetok	07-20-46	"	"
" "	USNM 388740	♀	A	Kabelle	"	"	"
" "	CNHM 153285	♂	?	--	06-18-46	"	M.A.Traylor,Jr.
" "	CNHM 153286	♀	?	--	05-19-46	"	"
" "	CNHM 153287	♂	I	--	"	"	"
" "	CNHM	♂	-	--	--	-	--
Anous stolidus	USNM 388771	♀	A	Mellu	06-19-46	Skin	J.P.E.Morrison
" "	USNM 388772	♂	A	Enybarbar	06-18-46	"	"
" "	USNM 388773	?	I	Naen	07-31-46	"	"
" "	USNM 388774	♂	A	Burok	07-24-46	"	"
Anous tenuirostris	USNM 388797	♂	A	Arbar	06-16-46	"	"
" "	USNM 388798	♂	A	Piganiyaro-yaro	07-30-46	"	"
" "	USNM 388799	♀	A	"	"	"	"
" "	USNM 388800	?	N	"	"	"	"
" "	USNM 388801	?	N	"	"	"	"
Gygis alba	USNM 388750	♀	A	Naen	07-31-46	"	"
" "	USNM 388752	♂	A	Enybarbar	06-18-46	"	"
" "	CNHM 153313	♂?	N	--	06-28-46	"	M.A.Traylor,Jr.
" "	CNHM 153314	♀	N	--	"	"	"
" "	CNHM 153315	♀	N	--	"	"	"
" "	CNHM 153316	♀	-	--	"	"	"
" "	CNHM 153317	♀	-	--	"	"	"
" "	CNHM 153318	♀	-	--	"	"	"
" "	CNHM	♀	-	--	--	"	"

348-415 O-69—10



11°10′N
AILINGINAE
0
1
2
STATUTE MILES
Sifo
Najibuen
Bokonikaiaru
Manchinikon
166°20′E
166°20′
Mogiri
Enibuk
Eniuetakku
(Eniwetakku)
Airuken
Ribinouri
Kuobuen
Pigessharukku
Ucchuwanen
166°30′
166°30′
Bokanchinre
Charaien
Kungeekan
Knox
Bokoen
Majokoryaan
Bokoryuren
11°10′

AILINGINAE ATOLL

Location: 11°08' N x 166°24' E.

Shape and Size: Narrow oblong-shaped; Tip to tip (east-west) - 15 miles; Width - 4 miles; Total lagoon area - 58.76 square miles, Total dry land area - 1.29 square miles; Number of islands - 25; Height - 10 feet(Fosberg, 1956).

Soil: Beach (seaward) - mostly beach rock, some cobblestone areas; Beach (lagoon) - mostly sand, some exposed rock and cobblestone areas; Interior - mostly sand, very little humus.

Vegetation: Species number unknown; larger islands, planted with Cocos, some Pemphis and low scrub on seaward side; smaller islands, low dense scrub, Pandanus, few Cocos.

Climate: Moderate rainfall, about 60-70 inches yearly; Mean air temperature - 82° F.; Winds - prevailing from east to north (Fosberg, 1956).

Human Population: Past - uninhabited; Present - uninhabited, evidence in 1967 of occasional visitors to gather copra.

Scientific Visits: U.S. Navy (F. R. Fosberg) - 10 February 1956; POBSP - 1 May 1967.

Avifauna: Fourteen bird species are known from Ailinginae Atoll. Nine of these species are seabirds, 4 are shorebirds, and 1 is a heron. Four species are known breeders, 6 others are potential breeders, while 4 are migrants.

The 14 species known from Ailinginae Atoll are included in the following checklist. The source material from which this list was compiled includes: (1) Fosberg, 1966; and (2) POBSP 1967 data. These sources are referred to in the checklist by the corresponding number. The nine species marked with a single asterisk are new species records for Ailinginae Atoll; the four species marked with double asterisks are new breeding records.

Ailinginae Atoll Avifauna Checklist

Species	Status	Source
1) *Sula sula**	Resident breeder ?	2
2) *Sula leucogaster**	Resident breeder ?	2
3) *Fregata minor**	Resident breeder ?	2
4) *Egretta sacra**	Resident breeder ?	2
5) *Pluvialis dominica**	Migrant	2
6) *Numenius tahitiensis*	Migrant	1, 2
7) *Heteroscelus incanum* *	Migrant	2
8) *Arenaria interpres*	Migrant	1, 2
9) *Sterna sumatrana**	Resident breeder ?	2
10) *Sterna fuscata**	Resident breeder**	2

Species	Status	Source
11) *Thalasseus bergii**	Resident breeder**	2
12) *Anous stolidus*	Resident breeder**	1, 2
13) *Anous tenuirostris*	Resident breeder**	1, 2
14) *Gygis alba*	Resident breeder ?	1, 2

Twenty-seven specimens of 10 bird species have been collected by POBSP personnel from Ailinginae Atoll (Table 21). These include six species whose specimens are the first to be collected from the atoll, and four whose specimens confirm a previous sight record. No other specimens have been collected from the atoll.

TABLE 21. Bird specimens collected by POBSP from Ailinginae Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Sula leucogaster	USNM 543355	?	SA	Airuken	5-1-67	Skin	Amerson
Fregata minor	" 543379	♀	A	"	"	"	"
Egretta sacra	" 543457	?	A	Eniuetakku	"	"	"
Numenius tahitiensis	" 498369	♂	A	Enibuk	"	Skel.	"
Arenaria interpres	" 543426	♂	A	"	"	Skin	"
" "	" 543427	?	A	"	"	"	"
Sterna sumatrana	" 543219	?	-	"	"	"	"
Sterna fuscata	" 543480	♂	A	Airuken	"	"	"
" "	" 543481	♂	A	"	"	"	"
" "	" 543482	♂	A	"	"	"	"
" "	" 543483	♀	I	"	"	"	"
" "	" 543484	♂	I	"	"	"	"
" "	" 543485	♀	I	"	"	"	"
" "	" 543390	♂	A	"	"	"	"
" "	" 543391	♂	A	"	"	"	"
" "	" 543392	♂	A	"	"	"	"
" "	" 543393	♂	A	"	"	"	"
" "	" 543394	♂	A	"	"	"	"
" "	" 543395	♂	I	"	"	"	"
Thalasseus bergii	" 543432	♂	A	"	"	"	"
Anous stolidus	" 543470	♀	A	Manchinikon	"	"	"
" "	" 543471	♂	A	"	"	"	"
" "	" 543472	♂	A	Enibuk	"	"	"
" "	" 543411	♀	A	Airuken	"	"	"
Gygis alba	" 543406	♂	A	"	"	"	"
" "	" 543405	♂	A	Manchinikon	"	"	"
" "	" 543404	♂	A	"	"	"	"

Species Accounts

1) Sula sula Red-footed Booby

Habitat -- May 1967 - flying over the southwest portion of the lagoon.

Numbers -- May 1967 - one adult observed over the lagoon, none seen on the islands visited.

Status -- Resident breeder? -- May 1967 - no evidence of breeding on islands visited.

Specimen Records -- None. This observation is a new species sight record for the atoll.

2) Sula leucogaster Brown Booby

Habitat -- May 1967 - roosting on rocky seaward beach of Ribinouri-Airuken, also flying over the lagoon.

Numbers -- May 1967 - Ribinouri-Airuken 3, lagoon 25.

Status -- Resident breeder? May 1967 - no evidence of breeding at Manchinikon, Enibuk, Eniwetakku, and Ribinouri-Airuken; probable breeder since adults, subadults, and immatures were observed.

Specimen Records -- Other - none; POBSP - 1 (Table 21). This collection represents a new species and specimen record for the atoll.

3) Fregata minor Great Frigatebird

Habitat -- May 1967 - adults and subadults flying above Manchinikon, Enibuk, Eniwetakku, and Ribinouri-Airuken and the lagoon.

Numbers -- May 1967 - Manchinikon 2, Enibuk 3, Eniwetakku 1, Ribinouri-Airuken 3, lagoon 6.

Status -- Resident breeder? -- May 1967 - no evidence of breeding on islands listed above but this species possibly breeds at Ailinginae Atoll.

Specimen Records -- Other - none; POBSP - 1 (Table 21). This is a new species and specimen record for the atoll.

4) Egretta sacra Reef Heron

Habitat -- May 1967 - present on sandy and rocky seaward beaches of Enibuk and Ribinouri-Airuken.

Numbers -- May 1967 - Enibuk 1, Ribinouri-Airuken 2.

Status -- Resident breeder? -- May 1967 - no evidence of breeding. This species possibly, however, nests on the atoll.

Specimen Records -- Other - none; POBSP - 1 (Table 21). This represents a new species and specimen record for Ailinginae Atoll.

5) Pluvialis dominica Golden Plover

Habitat -- May 1967 - on sandy and rocky beach areas of Enibuk, Eniwetakku, and Ribinouri-Airuken.

Numbers -- May 1967 - Enibuk 2, Eniwetakku 3, Ribinouri-Airuken 5.

Status -- Migrant.

Specimen Records -- None. This observation is a new species sight record for the atoll.

6) Numenius tahitiensis Bristle-thighed Curlew

Habitat -- February 1956 - present on Sifo (Fosberg, 1966); May 1967 - on rocky seaward areas of Enibuk, Eniwetakku, and Ribinouri-Airuken.

Numbers -- February 1956 - Sifo 2; May 1967 - Enibuk 2, Eniwetakku 3, Ribinouri-Airuken 2.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - 1 (Table 21). This represents a new specimen record for Ailinginae Atoll.

7) Heteroscelus incanum Wandering Tattler

Habitat -- May 1967 - on rocky beaches of Manchinikon, Enibuk, Eniwetakku, and Ribinouri-Airuken.

Numbers -- May 1967 - Manchinikon 2, Enibuk 1, Eniwetakku 1, Ribinouri-Airuken 2.

Status -- Migrant.

Specimen Records -- None. This observation is a new species sight record for the atoll.

8) Arenaria interpres Ruddy Turnstone

Habitat -- February 1956 - present on Sifo (Fosberg, 1966); May 1967 - on sandy and rocky beach areas of Enibuk, Eniwetakku, and Ribinouri-Airuken.

Numbers -- February 1956 - Sifo a few (Fosberg, 1966); May 1967 - Enibuk 5, Eniwetakku 4, Ribinouri-Airuken 6.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - 2 (Table 21). This is a new specimen record for the atoll.

9) Sterna sumatrana Black-naped Tern

Habitat -- May 1967 - on the rocky and sandy beach areas of Enibuk, Eniwetakku, and Ribinouri-Airuken; also flying over the lagoon.

Numbers -- May 1967 - Enibuk 6, Eniwetakku 3, Ribinouri-Airuken 5, lagoon 10.

Status -- Resident breeder? May 1967 - no nests observed on above islands.

Specimen Record -- Other - none; POBSP - 1 (Table 21). This is a new species and specimen record for the atoll.

10) Sterna fuscata Sooty Tern

Habitat -- May 1967 - colony on rocky western tip of Ribinouri-Airuken.

Numbers -- May 1967 - Ribinouri-Airuken 5,000 adults, 2,000 young.

Status -- Resident breeder. May 1967 - Ribinouri-Airuken 2,000 most young almost fledged, a few already flying, some dead (possibly killed by rats). This is a new breeding record for Ailinginae Atoll.

Specimen Records -- Other - none; POBSP - 12 (Table 21). This collection constitutes a new species and specimen record for the atoll.

11) Thalasseus bergii Crested Tern

Habitat -- May 1967 - flying over and roosting on rocky seaward areas of Enibuk, Eniwetakku, and Ribinouri-Airuken,flying over the lagoon; almost-fledged young on rocky seaward area of Ribinouri-Airuken.

Numbers -- May 1967 - Enibuk 2, Eniwetakku 2, Ribinouri-Airuken 25 adults and 9 young, lagoon 5.

Status -- Resident breeder. May 1967 - Ribinouri-Airuken 9 almost-fledged young present. This is a new breeding record for Ailinginae Atoll.

Specimen Records -- Other - none; POBSP - 1 (Table 21). This collection represents a new species and specimen record for the atoll.

12) *Anous stolidus* Brown Noddy

Habitat -- February 1956 - present on Sifo (Fosberg, 1966); May 1967 - roosting and nesting in *Pandanus* on Manchinikon, Enibuk, Eniwetakku, and Ribinouri-Airuken, also flying over lagoon.

Numbers -- February 1967 - Sifo a few present; May 1967 - Manchinikon 100, Enibuk 50, Eniwetakku 100, Ribinouri-Airuken 200, lagoon few.

Status -- Resident breeder. May 1967 - nests with eggs on Manchinikon, Enibuk, Eniwetakku, and Ribinouri-Airuken. This is a new breeding record for the atoll.

Specimen Records -- Other - none; POBSP - 4 (Table 21). This is a new specimen record for the atoll.

13) *Anous tenuirostris* Black Noddy

Habitat -- February 1956 - present on Sifo (Fosberg, 1966); May 1967 - flying above, roosting and nesting in *Pisonia* at Manchinikon, Enibuk, Eniwetakku, Ribinouri-Airuken, also over lagoon.

Numbers -- February 1956 - Sifo several; May 1967 - Manchinikon 25, Enibuk 10, Eniwetakku 10, Ribinouri-Airuken 50, and lagoon few.

Status -- Resident breeder. May 1967 - old nests observed at Manchinikon, Enibuk, Eniwetakku, and Ribinouri-Airuken. This is a new breeding record.

Specimen Records -- None.

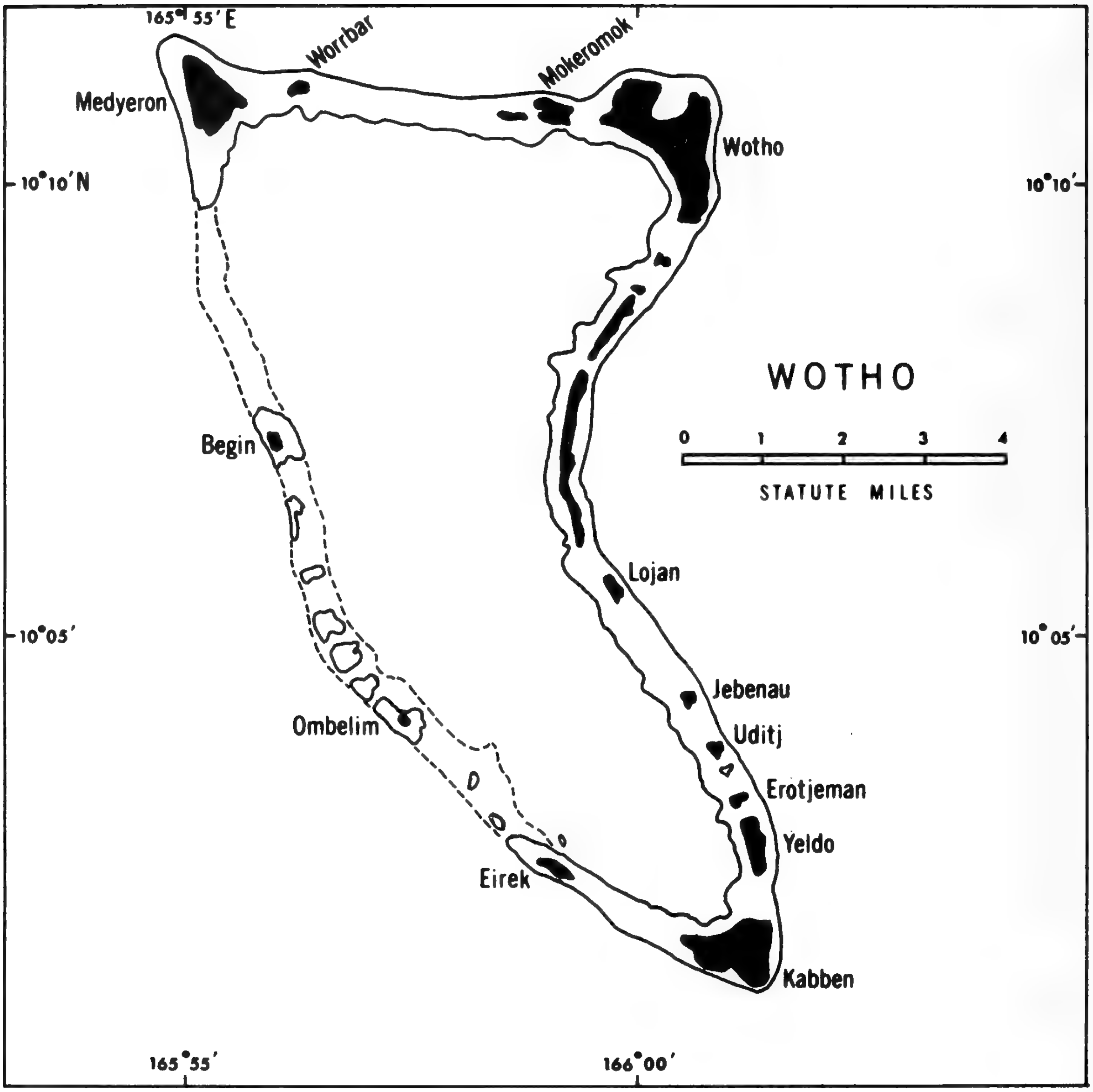
14) *Gygis alba* White Tern

Habitat -- February 1956 - present on Sifo (Fosberg, 1966); May 1967 - flying above and roosting in *Pisonia* and *Cocos* at Manchinikon, Enibuk, Eniwetakku, and Ribinouri-Airuken, also flying over lagoon.

Numbers -- February 1956 - Sifo 100's; May 1967 - Manchinikon 100, Enibuk 100, Eniwetakku 50, Ribinouri-Airuken 100, lagoon few.

Status -- Resident breeder? May 1967 - no eggs or young observed on Manchinikon, Enibuk, Eniwetakku, or Ribinouri-Airuken. Specimens collected had bare brood patches.

Specimen Records-- Other - none; POBSP - 3 (Table 21). This collection constitutes a new specimen record for Ailinginae Atoll.



165° 55′ E
Worrbar
Mokeromok
Medyeron
Wotho
10°10′N
10°10′
WOTHO
0
1
2
3
4
STATUTE MILES
Begin
Lojan
10°05′
10° 05′
Jebenau
Ombelim
Uditj
Erotjeman
Yeldo
Eirek
Kabben
165°55′
166°00′

WOTHO ATOLL

Location: 10°06' N x 165°59' E.

Shape and Size: Irregular triangular-shaped; base to tip (north-southeast) - 19 miles; Width (north base) - 9 miles; Total lagoon area - 45.84 square miles; Total dry land area - 1.60 square miles; Number of islands - 15; Height - ? feet (Fosberg, 1956).

Soil: No available data.

Vegetation: Forty species; larger islands with some original forests, large areas of planted *Cocos*; smaller islands with scrub cover and small trees (Fosberg, 1956).

Climate: Moderately wet, about 70-100 inches of rainfall yearly; Mean air temperature - 82° F.; Wind - prevailing from east to north (Fosberg, 1956).

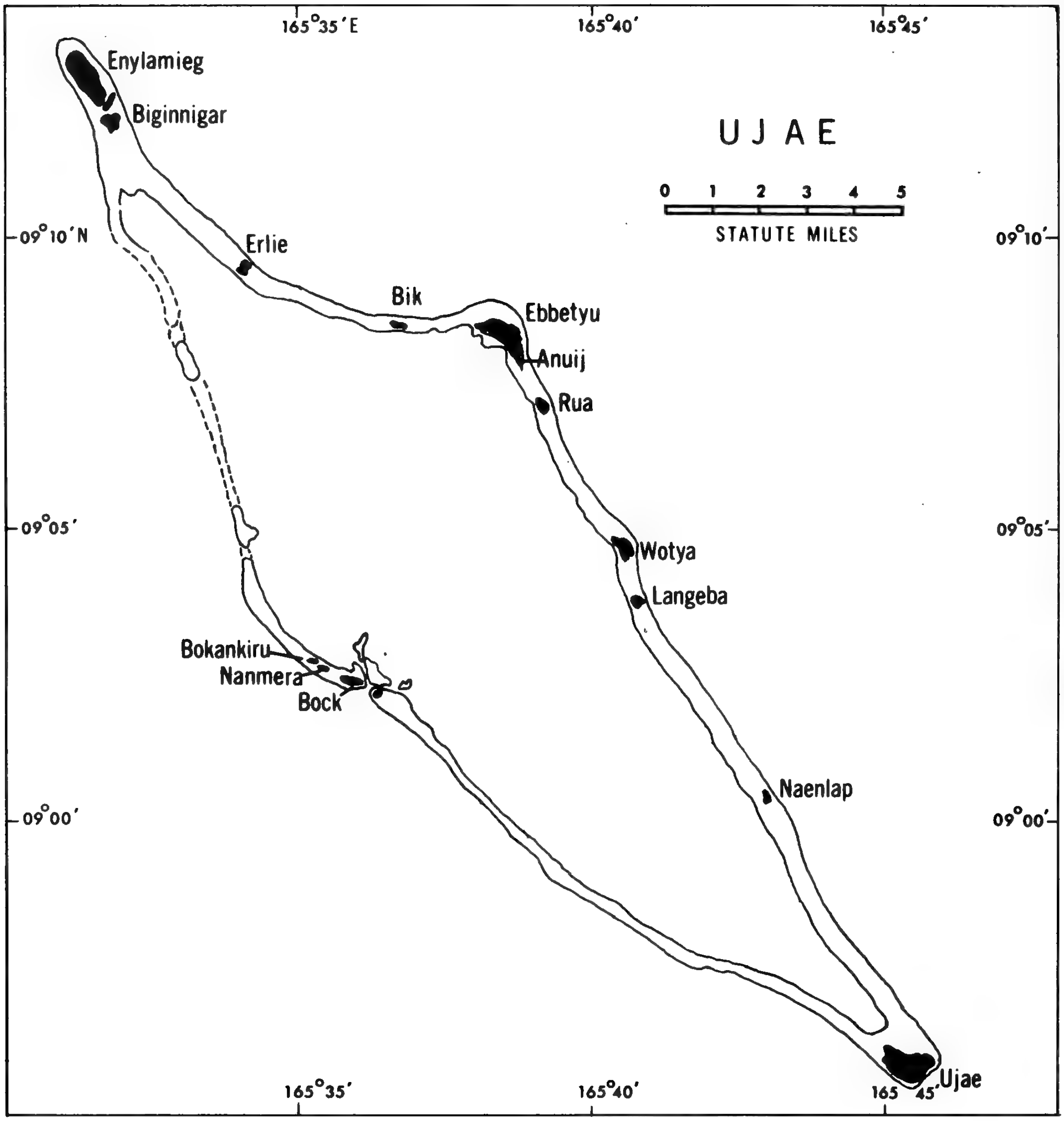
Human Population: Past - inhabited, 40 in 1800's (Findlay, 1886); 31 in 1948 (Freeman, 1951); Present - inhabited, 54 in 1964 (U.S. Department of State, 1965).

Scientific Visits: U.S. Geological Survey Expedition (F. R. Fosberg) - 12-16 February, 18-22 March 1952.

Avifauna: Fifteen bird species are known from Wotho Atoll. These include 7 seabird species, 5 shorebord species, 1 heron, 1 domestic duck, and 1 domestic fowl. Only three species of the 10 potential breeders are known to breed on the atoll. No museum specimens are known.

Fosberg (1966) observed the following species from Wotho Atoll:

1)	*Sula leucogaster*	Resident breeder ?
2)	*Fregata minor*	Resident breeder ?
3)	*Egretta sacra*	Resident breeder ?
4)	*Cairina moschata*	Introduced breeder ?
5)	*Gallus gallus*	Introduced breeder ?
6)	*Pluvialis dominica*	Migrant
7)	*Numenius phaeopus*	Migrant
8)	*Numenius tahitiensis*	Migrant
9)	*Heteroscelus incanum*	Migrant
10)	*Arenaria interpres*	Migrant
11)	*Sterna sumatrana*	Resident breeder ?
12)	*Thalasseus bergii*	Resident breeder ?
13)	*Anous stolidus*	Resident breeder, February (downy young)
14)	*Anous tenuirostris*	Resident breeder, February-March
15)	*Gygis alba*	Resident breeder, February (eggs)



165°35′E
165°40′
165°45′
UJAE
0 1 2 3 4 5
STATUTE MILES
09°10′N
09°10′
09°05′
09°05′
09°00′
09°00′
Enylamieg
Biginnigar
Erlie
Bik
Ebbetyu
Anuij
Rua
Wotya
Langeba
Bokankiru
Nanmera
Bock
Naenlap
Ujae
165°35′
165°40′
165 45′

UJAE ATOLL

Location: 09°05' N x 165°40' E.

Shape and Size: Elongated diamond-shaped; Tip to tip (northwest-southeast) - 27 miles; Widest Point - 8 miles; Total lagoon area - 83.51 square miles; Total dry land area - 0.62 square miles; Number of islands - 15; Height - ? feet (Fosberg, 1956).

Soil: No available data.

Vegetation: Sixty-one species; large islands planted with *Cocos*, smaller islands original scrub and patches of forest (Fosberg, 1956).

Climate: Moderately wet, about 70-100 inches of rainfall yearly; Mean air temperature - 82° F.; Wind - prevailing from east to north (Fosberg, 1956).

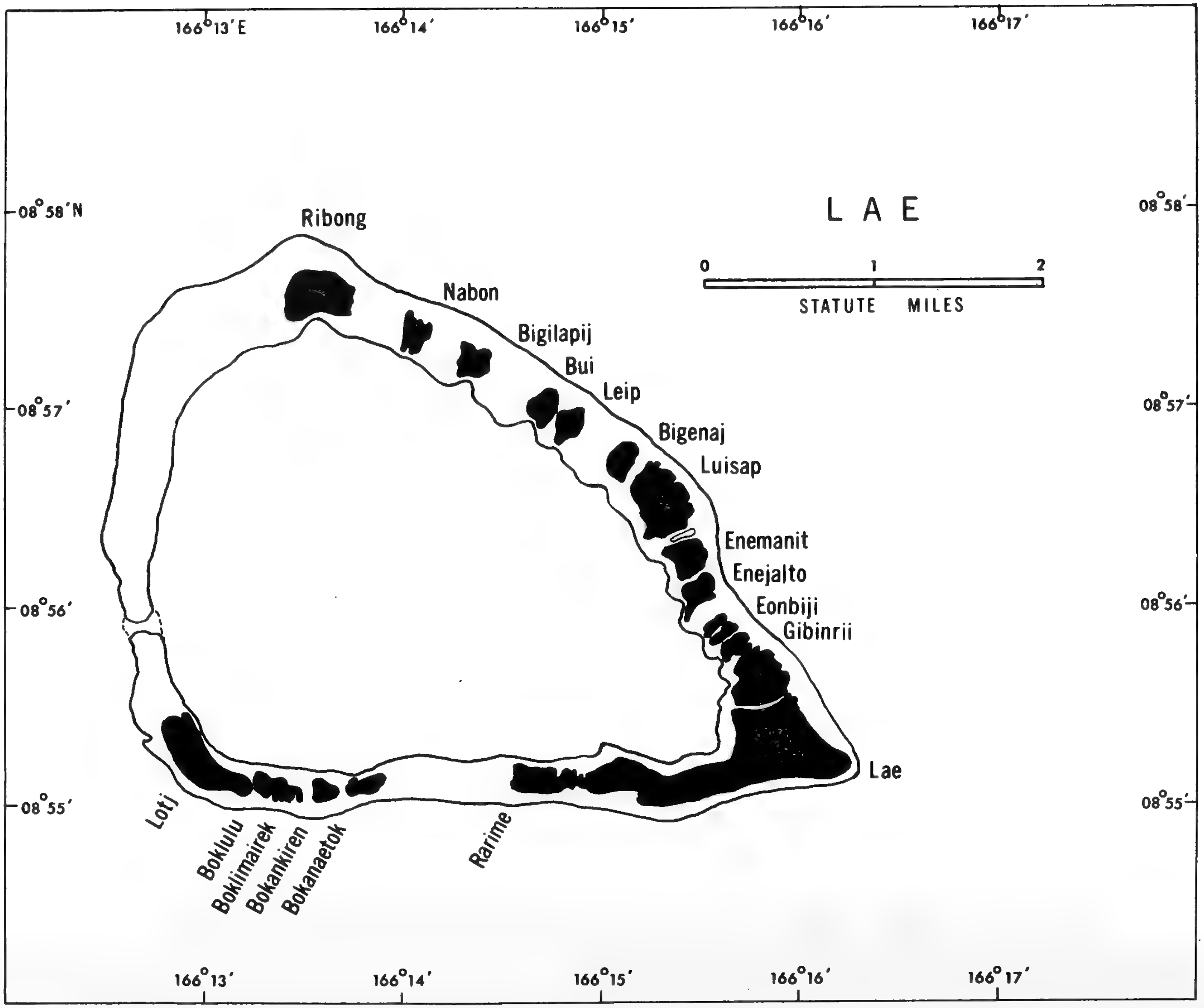
Human Population: Past - inhabited, 300 in 1800's (Findlay, 1886); 244 in 1948 (Freeman, 1951); Present - inhabited, 230 in 1964 (U.S. Department of State, 1965).

Scientific Visits: U.S. Geological Survey Expedition (F. R. Fosberg) - 16-23 February, 2-13 March 1952.

Avifauna: Fourteen bird species are known from Ujae Atoll. These species include 8 seabirds, 5 shorebirds, and 1 heron. Although 9 species are potential breeders, only 4 are known breeders. No museum specimens have been collected from the atoll.

Fosberg (1966) listed the following species which he observed on the atoll:

1)	*Sula sula*	Resident breeder ?
2)	*Sula leucogaster*	Resident breeder ?
3)	*Fregata minor*	Resident breeder ?
4)	*Egretta sacra*	Resident breeder ?
5)	*Pluvialis dominica*	Migrant
6)	*Numenius phaeopus*	Migrant
7)	*Numenius tahitiensis*	Migrant
8)	*Heteroscelus incanum*	Migrant
9)	*Arenaria interpres*	Migrant
10)	*Sterna sumatrana*	Resident breeder, February-March (eggs)
11)	*Thalasseus bergii*	Resident breeder ?
12)	*Anous stolidus*	Resident breeder, February-March (eggs)
13)	*Anous tenuirostris*	Resident breeder, February (young)
14)	*Gygis alba*	Resident breeder, February (eggs to large young)


LAE
0
1
2
STATUTE MILES
166°13′E
166°14′
166°15′
166°16′
166°17′
08°58′N
08°57′
08°56′
08°55′
Ribong
Nabon
Bigilapij
Bui
Leip
Bigenaj
Luisap
Enemanit
Enejalto
Eonbiji
Gibinrii
Lae
Rarime
Bokanaetok
Bokankiren
Boklimairek
Boklulu
Lotj

LAE ATOLL

Location: 08°56' N x 166°14' E.

Shape and Size: Irregular triangle-shaped; Base to tip (west-southeast) - 5 miles; Width (west base) - 3.5 miles; Total lagoon area - 10.08 square miles; Total dry land area - 0.60 square miles; Number of islands - 15; Height - 8 feet (Fosberg, 1956).

Soil: Beach (seaward) - mostly rocky, but some sandy areas; Beach (lagoon) - mostly sandy (Fosberg, 1956).

Vegetation: Sixty-three species; most islands planted with Cocos, some thick wooded areas and some sparse tall scrub (Fosberg, 1956).

Climate: Moderately wet, about 70-100 inches of rainfall yearly; Mean air temperature - 82° F., Winds - prevailing from east to north (Fosberg, 1956).

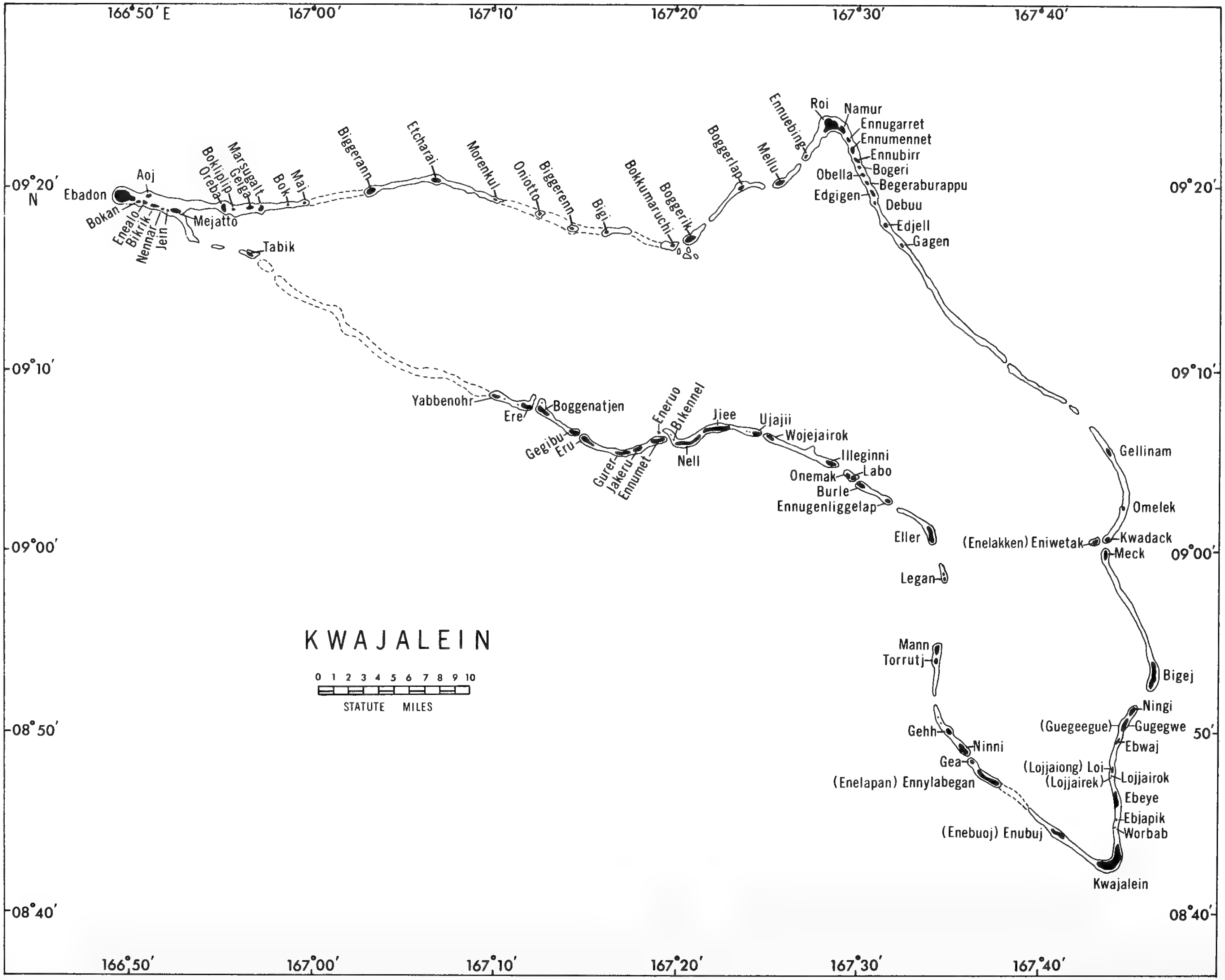
Human Population: Past - inhabited, 250 in 1800's (Findlay, 1886); 138 in 1948 (Freeman, 1951); Present - inhabited 143 in 1964 (U.S. Department of State, 1965).

Scientific Visits: U.S. Geological Survey Expedition (F. R. Fosberg) - 6-10 January 1952.

Avifauna: Ten bird species have been recorded from Lae Atoll. Of these species, 4 are seabirds, 4 are shorebirds, 1 is a heron, and 1 is a domestic fowl. Potential breeders include 6 species, but only 1 is known to breed. No museum specimens are known from the atoll.

Fosberg (1966) observed the following species from Lae Atoll:

1)	Egretta sacra	Resident breeder ?
2)	Gallus gallus	Introduced breeder ?
3)	Pluvialis dominica	Migrant
4)	Numenius phaeopus	Migrant
5)	Heteroscelus incanum	Migrant
6)	Arenaria interpres	Migrant
7)	Thalasseus bergii	Resident breeder ?
8)	Anous stolidus	Resident breeder, January
9)	Anous tenuirostris	Resident breeder ?
10)	Gygis alba	Resident breeder ?


KWAJALEIN
0 1 2 3 4 5 6 7 8 9 10
STATUTE MILES
166°50′E
167°00′
167°10′
167°20′
167°30′
167°40′
09°20′ N
09°10′
09°00′
08°50′
08°40′
50′
Ebadon
Aoj
Bokan
Enealo
Bikrik
Nennar
Jein
Mejatto
Oreba
Bokliplip
Geiga
Marsugalt
Bok
Maj
Tabik
Biggerann
Etcharai
Morenkul
Oniotto
Biggerenn
Bigi
Bokkumaruchi
Boggerik
Boggerlap
Mellu
Ennuebing
Roi
Namur
Ennugarret
Ennumennet
Ennubirr
Obella
Bogeri
Begeraburappu
Edgigen
Debuu
Edjell
Gagen
Yabbenohr
Ere
Boggenatjen
Gegibu
Eru
Gurer
Jakeru
Ennumet
Eneruo
Bikennel
Nell
Jiee
Ujajii
Wojejairok
Illeginni
Onemak
Labo
Burle
Ennugenliggelap
Eller
Legan
Gellinam
Omelek
(Enelakken) Eniwetak
Kwadack
Meck
Mann
Torrutj
Bigej
Gehh
Ninni
Gea
(Enelapan) Ennylabegan
(Enebuoj) Enubuj
Ningi
(Guegeegue)
Gugegwe
Ebwaj
(Lojjaiong) Loi
(Lojjairek)
Lojjairok
Ebeye
Ebjapik
Worbab
Kwajalein

KWAJALEIN ATOLL

Location: 09°05' N x 167°20' E.

Shape and Size: An irregular-shaped crescent (running from southeast to northwest); Tip to tip - 75 miles, reef length 195 miles; Total lagoon area - 901.73 square miles; Total land area - 5.63 square miles; Number of islands - 92 (Fosberg, 1956).

Soil: Beach - sandy with coral rock outcrops; Inland - sand to humus (may vary from island to island).

Vegetation: Species present - 77; Composition varies from island to island, *Cocos*, *Pisonia*, and *Messerschmidia* prominent.

Climate: Moderately wet, average annual rainfall 96 inches; Mean annual temperature - 82° F.; Wind, prevalent from northeast (Fosberg, 1956).

Human Population: Past - inhabited, 200 in 1800's (Findlay, 1886); 1,043 in 1948 (Freeman, 1951); Present - inhabited, 2,663 natives in 1964 plus U.S. military personnel (U.S. Department of State, 1965).

Scientific Visits: Herbert Wallace - 1944; Northern Marshall Islands Expedition - 15-28 January, 29 February, 15 March 1952, 2-12 February 1956, and several brief stops on other dates (Fosberg, 1966); Charles F. Yocom - 20-30 July 1960; POBSP - 29 October to 9 November 1964, 13-19 June 1966.

Avifauna: Thirty species of birds are now known from Kwajalein Atoll. These include 10 seabirds, 11 shorebirds, 6 ducks, 1 heron, and 2 landbirds. Of these 30 species, 4 are known breeders, 9 are possible breeders, 9 are regular migrants, 1 is a common visitor, and 7 are accidentals.

Kwajalein Atoll is the only locality in the Marshall and Gilbert Islands from which *Anas platyrhynchos*, *Anas strepera*, *Aythya fuligula*, *Capella hardwickii*, *Acridotheres tristis*, and *Passer domesticus* have been recorded.

Thirty species are listed in the following checklist, which was derived from various sources: (1) POBSP, (a) 1964, (b) 1966, (c) band return data; (2) Fosberg, 1966; (3) Baker, 1951; (4) Yocom, 1964; and (5) Marshall, 1957. These sources are referred to in the checklist by the corresponding numbers and letters. The seven species marked by a single asterisk are new species records for Kwajalein Atoll.

Kwajalein Atoll Avifauna Checklist

	Species	Status	Source
1)	*Sula sula**	Resident breeder ?	1a
2)	*Sula leucogaster*	Resident breeder ?	1b, 2b
3)	*Fregata minor*	Resident breeder ?	1a, 2b, 3
4)	*Egretta sacra*	Resident breeder ?	1a, 2b, 3, 4,
5)	*Anas platyrhynchos*	Accidental	4
6)	*Anas crecca*	Accidental	4
7)	*Anas strepera*	Accidental	4
8)	*Anas acuta*	Common visitor	1a, 4
9)	*Anas clypeata*	Accidental	1a, 4
10)	*Aythya fuligula**	Accidental	1a
11)	*Pluvialis dominica*	Migrant	1ab, 2b
12)	*Squatarola squatarola**	Accidental	1a
13)	*Numenius phaeopus*	Migrant	1a, 2b
14)	*Numenius tahitiensis**	Migrant	1a
15)	*Limosa lapponica*	Migrant	1a, 2b
16)	*Heteroscelus brevipes*	Migrant	1a, 4
17)	*Heteroscelus incanum*	Migrant	1ab, 2b, 4
18)	*Arenaria interpres*	Migrant	1abc, 2b, 4
19)	*Capella hardwickii**	Accidental	1a
20)	*Crocethia alba**	Migrant	1a
21)	*Erolia acuminata**	Migrant	1ab
22)	*Sterna sumatrana*	Resident breeder ?	1ab, 2b
23)	*Sterna lunata*	Resident breeder ?	4
24)	*Sterna fuscata*	Resident breeder ?	1c, 2b, 4
25)	*Thalasseus bergii*	Resident breeder ?	1ab, 2b
26)	*Anous stolidus*	Resident breeder	1ab, 2b, 3
27)	*Anous tenuirostris*	Resident breeder	1ab, 2b
28)	*Gygis alba*	Resident breeder	1ab, 2b, 3, 4
29)	*Passer domesticus**	Resident breeder ?	1a
30)	*Acridotheres tristis*	Resident breeder, now absent	2ab, 5

POBSP personnel have collected 58 specimens of 16 species (Table 22). Of these 16 species, 5 are species not previously known from Kwajalein Atoll; the other 11 represent the first specimen confirmation of species previously known only from sight records. No other specimens are known from Kwajalein Atoll.

TABLE 22. Bird specimens collected by POBSP from Kwajalein Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anas acuta	USNM 494843	♂	-	Kwajalein I	11-02-64	Skin	Clapp
" "	USNM 494844	♀	-	"	"	"	"
" "	USNM 494845	♀	-	"	11-03-64	"	Huber
" "	USNM 494846	♀	-	"	"	"	"
" "	USNM 494847	♂	-	"	11-09-64	"	"
" "	USNM 494848	♀	-	"	"	"	"

TABLE 22. Bird specimens collected by POBSP from Kwajalein Atoll (cont.)

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anas clypeata	USNM 494849	♂	-	Kwajalein I	11-03-64	Skin	Huber
" "	USNM 494850	?	-	"	"	"	"
Aythya fuligula	USNM 494852	♀	-	"	11-02-64	"	Clapp
Pluvialis dominica	USNM 494747	♂	-	Roi-Namur	11-04-64	"	"
" "	USNM 494748	♀	=	Kwajalein I	11-09-64	"	Huber
" "	USNM 494749	♂	-	"	"	"	"
" "	USNM 494751	♀	-	"	"	"	"
" "	USNM 494752	♂	-	"	"	"	"
Squatarola squatarola	USNM 494822	♀	-	"	11-03-64	"	"
Numenius phaeopus	USNM 494837	♂	-	"	11-02-64	"	Clapp
" "	USNM 494838	♂	-	"	11-03-64	"	Huber
" "	USNM 494839	♀	-	"	"	"	"
" "	USNM 494840	♀	-	"	"	"	"
Limosa lapponica	USNM 494830	♂	-	Roi-Namur	11-04-64	"	Clapp
Heteroscelus incanum	USNM 494898	?	-	"	"	"	"
" "	USNM 494914	?	-	"	"	"	"
" "	USNM 494915	♂	-	"	"	"	"
Heteroscelus brevipes	USNM 494899	♀	Imm	"	"	"	"
" "	USNM 494912	♀	A	"	"	"	"
" "	USNM 494913	♀	-	"	"	"	"
Arenaria interpres	USNM 494763	♀	-	"	"	"	"
" "	USNM 494764	♀	-	"	"	"	"
" "	USNM 494765	♀	-	"	"	"	"
" "	USNM 494766	♂	-	"	"	"	"
" "	USNM 494767	♀	-	"	"	"	"
" "	USNM 494768	♀	-	"	"	"	"
" "	USNM 494769	?	-	"	"	"	"
" "	USNM 494770	♀	-	"	"	"	"
" "	USNM 494771	♀	-	"	"	"	"
" "	USNM 494772	♀	-	"	"	"	"
" "	USNM 494773	♀	-	"	"	"	"
" "	USNM 494774	♂	-	"	"	"	"
Capella (Gallinago) hardwickii	USNM 494842	♂	-	Kwajalein I	11-03-64	"	Wislocki
Crocethia alba	USNM 494795	♀	-	"	11-02-64	"	Clapp
" "	USNM 494796	♂	-	"	11-03-64	"	Huber
Erolia acuminata	USNM 494797	♀	-	"	11-02-64	"	Clapp
" "	USNM 494798	♀	-	"	"	"	"
" "	USNM 494799	♀	-	"	"	"	"
" "	USNM 494800	♂	-	"	"	"	"
" "	USNM 494801	?	-	"	"	"	"
" "	USNM 494802	?	-	"	"	"	"
" "	USNM 494803	♀	-	"	11-04-64	"	Huber
" "	USNM 494804	♀	-	"	"	"	"
" "	USNM 494805	♀	-	"	"	"	"
Anous stolidus	USNM 494663	♂	-	Loi	11-08-64	"	Clapp
" "	USNM 494664	♂	-	"	"	"	"
" "	USNM 494665	♀	-	"	"	"	"

TABLE 22. Bird specimens collected by POBSP from Kwajalein (cont.).

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anous tenuirostris	USNM 494547	♀	-	Ebeye (lagoon)	11-08-64	Skin	Amerson
" "	USNM 494548	♀	-	"	"	"	"
" "	USNM 494549	♀	-	N. Loi	"	"	Clapp
" "	USNM 494550	♂	-	"	"	"	"
Gygis alba	USNM 494632	♀	-	"	"	"	"

Species Accounts

1. Sula sula Red-footed Booby

Habitat -- October-November 1964 - seen flying offshore of Roi-Namur on 30 October. This species possibly roosts on some of the many uninhabited islands in the atoll.

Numbers -- October-November 1964 - five observed (four of which were immature or dark-phase birds) offshore of Roi-Namur on 30 October.

Status -- Resident breeder? Breeding not observed. This species may nest on some of the many isolated islands in the atoll.

Specimen Records -- None. This is a new species sight record for Kwajalein Atoll.

2) Sula leucogaster Brown Booby

Habitat -- 23 January 1952 - seen flying with frigatebirds (Fosberg, 1966); June 1966 - observed sitting on buoys inside the lagoon (14 June) and flying (feeding) outside the atoll (15 June).

Numbers -- 23 January 1952 - one seen (Fosberg, 1966); June 1966 - adults sitting on buoys, four feeding outside the atoll.

Status -- Resident breeder? Not known to breed, however, may breed on some of the many islands that have not been visited by ornithologists.

Specimen Records -- None.

3) Fregata minor Great Frigatebird

Habitat -- 7 May 1944 - observed at Loi by Wallace (Baker, 1951); 19, 23 January 1952 and 2 February 1956 - soaring over Kwajalein Island (Fosberg, 1966); October-November 1964 - flying over Roi-Namur on 30 October, flying over Kwajalein Island on 9 November. This species probably roosts on some of the nonfrequented islands in the atoll.

Numbers -- 7 May 1944 - two seen at Loi (Baker, 1951); 19 January 1952 - one, 23 January 1952 - many dozens, and 2 February 1956 - two seen over Kwajalein Island (Fosberg, 1966); 29 October 1964 - one over Roi-Namur; 9 November 1964 - one over Kwajalein Island.

Status -- Resident breeder? October-November 1964 - not observed breeding; may breed on unvisited islands.

Specimen Records -- None.

4) Egretta sacra Reef Heron

Habitat -- 1944-1945 - present (Baker, 1951); January, March, August 1952 - present on Lojjaiong, Lojjairek, Enebuoj, Ebeye, Kwajalein, and Enelakken (Fosberg, 1966); 25-27 July 1960 - three color phases present (Yocom, 1964); October-November 1964 - seen on sandy and rocky beaches of Roi-Namur and Loi.

Numbers -- 1944-1945 - "Wallace (field notes) found white herons more numerous than gray ones ..." (Baker, 1951); 15 January 1952 - Lojjaiong and Lojjairek 1 blue, 2 mottled, 2 white, 19 January 1952 - Enebuoj 1 mottled, 1 white, 26 January 1952 - Ebeye 1 white with wing tips dark, 1 white, 27 January 1952 - Kwajalein 1 blue, 1 white, 15 March 1952 - Kwajalein 1 blue, 3 August 1952 - Enelakken 1 blue, 1 mottled, 1 white (Fosberg, 1966); 25-27 July 1960 - "about 12 ... of the three color phases, white, white and black (mottled), and dark gray" (Yocom, 1964); October-November 1964 - Roi-Namur observed 4 various color-phased birds, Loi 1 seen.

Status -- Resident breeder? October-November 1964 - Breeding not observed, but may nest on the many isolated islands in the atoll.

Specimen Records -- None.

5) Anas platyrhynchos Mallard

Habitat -- Winter of 1959-1960 - W. W. Fennell observed Mallards at Kwajalein Island which arrived in September 1959 and remained until the last of February 1960 (Yocom, 1964).

Numbers -- Winter of 1959-1960 - "... two flocks ... consisting of about 12 birds each ..." (Yocom, 1964).

Status -- Accidental.

Specimen Records -- None.

6) Anas crecca Common or Green-winged Teal

Habitat -- September 1959-February 1960 - W. W. Fennell observed Common or Green-winged Teal on Kwajalein (Yocom, 1964).

Numbers -- September 1959-February 1960 - "... about 75 teal in one flock" (Yocom, 1964).

Status -- Accidental.

Specimen Records -- None.

7) Anas strepera Gadwall

Habitat -- September 1959-February 1960 - W. W. Fennell saw Gadwalls at Kwajalein (Yocom, 1964).

Numbers -- September 1959-February 1960 - "... considered ... the most numerous species present ..." (Yocom, 1964).

Status -- Accidental.

Specimen Records -- None.

8) Anas acuta Pintail

Habitat -- September 1959-February 1960 - W. W. Fennell observed Pintails on Kwajalein (Yocom, 1964); October-November 1964 - Kwajalein Island on fresh water "ponds" at edges (run-off areas) of runways, Roi-Namur in cleared areas in dense vegetation on Namur.

Numbers -- September 1959-February 1960 - several seen (Yocom, 1964); October-November 1964 - Kwajalein Island six seen and collected. Roi-Namur one seen (?).

Status -- Common visitor.

Specimen Records -- Other - none; POBSP - six (Table 22). Although Pintails have previously been observed from Kwajalein Atoll, these are the first specimen records from the atoll.

9) Anas clypeata Shoveler

Habitat -- September 1959-February 1960 - W. W. Fennell saw Shovelers on Kwajalein (Yocom, 1964); October-November 1964 - observed on fresh water drainage "ponds" on edge of runway at Kwajalein Island.

Numbers -- September 1959-February 1960 - Shovelers were seen (at least one shot) on Kwajalein (Yocom, 1964); October-November 1964 - two seen and collected on Kwajalein Island.

Status -- Accidental.

Specimen Records -- Other - none; POBSP - two (Table 22). This collection is a first specimen record for this species from Kwajalein Atoll.

10) Aythya fuligula Tufted Duck

Habitat -- October-November 1964 - observed on fresh-water drainage areas ("ponds") at edges of runways on Kwajalein Island.

Numbers -- October-November 1964 - one seen and collected on Kwajalein Island.

Status -- Accidental.

Specimen Records -- Other - none; POBSP - one (Table 22). This is a new species and specimen record for Micronesia.

11) Pluvialis dominica Golden Plover

Habitat -- 15 January 1952 - Kwajalein Island on lagoon debris flat, 19 January 1952 - outer reef flat and inner beach, 23 January 1952 and 29 February 1952, 3 August 1952, 12 February 1956, and 10 October 1960 - resting on the asphalt of the airstrips (Fosberg, 1966); October-November 1964 - common on the runways and grassy lawns of Kwajalein Island and Roi-Namur, present on the beaches of the above two islands and Loi, Bigej, and Ebeye; June 1966 - on the greens of the golf course and on the shoreline of Kwajalein Island.

Numbers -- Kwajalein Island: 15 January 1952 - 12 seen on lagoon flat, 19 January 1952 - a number on outer reef flat and inner beach, 23 January, 29 February, and 3 August 1952 - seen in numbers on the airstrip (5 together in August), 12 February 1956 - seen, 10 October 1960 - common generally on the island and a number on the airstrip (Fosberg, 1966); October-November 1964 - Kwajalein 200, Roi-Namur 200, Loi 10, Bigej 4, Ebeye 3-6; June 1966 - Kwajalein 16.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - five (Table 22). Although Golden Plovers are already known from Kwajalein Atoll, these are the first specimen records for this species from the atoll.

12) Squatarola squatarola Black-bellied Plover

Habitat -- 3 November 1964 - on runway of Kwajalein Island.

Numbers -- 3 November 1964 - one seen and collected on Kwajalein Island.

Status -- Accidental.

Specimen Records -- Other - none; POBSP - one (Table 22). This is a new species and specimen record from Kwajalein Atoll. There is only one other record (a sighting) for this species from the Marshall Islands (see Eniwetok Atoll).

13) <u>Numenius phaeopus</u> Whimbrel

Habitat -- 19 October 1950 - "... curlews, Whimbrels judging from their notes, were seen on the Kwajalein airstrip in the sun at 3:15 p.m. ..." (Fosberg, 1966); October-November 1964 - observed on runways and surrounding open areas of Kwajalein and Roi-Namur.

Numbers -- 19 October 1960 - two observed (Fosberg, 1966); October-November 1964 - Kwajalein 8; Roi-Namur 8.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - four (Table 22). These specimens represent the first specimen records from the atoll.

14) <u>Numenius tahitiensis</u> Bristle-thighed Curlew

Habitat -- October-November 1964 - observed only on runways and sandy beach areas of Roi-Namur.

Numbers -- October-November 1964 - Roi-Namur four seen.

Status -- Migrant.

Specimen Records -- None. This observation is a new sight record for Kwajalein Atoll.

15) <u>Limosa lapponica</u> Bar-tailed Godwit

Habitat -- 2 February 1956 - seen on weedy ground at southwest end of Kwajalein Island, also flew over the sea, circled around, and finally landed on the airstrip (Fosberg, 1966); 4 November 1964 - on taxi strip next to runway on Roi-Namur.

Numbers -- 2 February 1956 - one tentatively identified as this species seen on Kwajalein Island (Fosberg, 1966); 4 November 1964 - one seen and collected on Roi-Namur.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - one (Table 22). This is a new specimen record for Kwajalein Atoll.

16) <u>Heteroscelus brevipes</u> Polynesian Tattler

Habitat -- 4 November 1964 - on runways and taxi strips at Roi-Namur.

Numbers -- 4 November 1964 - three collected. Possibly some of those identified as <u>H. incanum</u> in the field were <u>H. brevipes</u>, for it is extremely difficult to distinguish the two species in their summer plumage without specimens.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - three (Table 22). These Polynesian Tattlers represent a new specimen record for Kwajalein Atoll. Yocom (1964) stated that the three Wandering Tattlers he observed at Kwajalein Atoll in 1960 could have been H. brevipes.

17) Heteroscelus incanum Wandering Tattler

Habitat -- 15, 19 January 1952 and 2 February 1956, outer reef flat and beach area (Fosberg, 1966); 25-27 July 1960, on Kwajalein and Guegeegue (Yocom, 1964); October-November 1964, on runways and outer beach areas of Loi and Bigej; 17 June 1966, observed around the shoreline of Kwajalein Island.

Numbers -- 15 January 1952 - "...several were seen...", 19 January 1952 - "...8 were seen at once, and others before and after...", 2 February 1956 - "...two were seen..." (Fosberg, 1966); 25-27 July 1960 - "...3 Wandering (?) Tattlers (Heteroscelus incanum) on Kwajalein, and 1 on Guegeegue Island..." (Yocom, 1964); October-November 1964 - Kwajalein 1520, Roi-Namur 25, Loi 5-10, Bigej 6; 17 June 1966 - Kwajalein 2.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - three (Table 22). This is a new specimen record from Kwajalein Atoll; it was previously known only from a sight record.

18) Arenaria interpres Ruddy Turnstone

Habitat -- July 1960 - "...on the runway at Kwajalein and ... on another island in the atoll..." (Yocom, 1964); 19 October 1960 - on the airstrip at Kwajalein Island (Fosberg, 1966); October-November 1964 - present on the runways, lawns, and beaches of Kwajalein and Roi-Namur, also on the beaches of Loi; June 1966 - around the shore line of Kwajalein (17 June), also seen flying over the lagoon (14 June).

Numbers -- July 1960 - Kwajalein 30 and a flock on another island (Yocom, 1964); 19 October 1964 - a considerable flock on Kwajalein Island (Fosberg, 1966); October - November 1964 - Kwajalein 200-300, Roi-Namur 200, Loi 25; 13-19 June 1966 - four flying over lagoon, about 30 on Kwajalein.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - twelve (Table 22). Although Ruddy Turnstones have previously been observed from Kwajalein Island, this series of skins is the first of the species to be collected from the atoll.

19) <u>Capella</u> (<u>Gallinago</u>) <u>hardwickii</u> Latham's Snipe

Habitat -- 3 November 1964 - grassy area between the runway and taxiway on Kwajalein.

Number -- 3 November 1964 - 1 seen and collected.

Status -- Accidental.

Specimen Records -- Other - none; POBSP - one (Table 22). This is a new species and specimen record for all of Micronesia.

20) <u>Crocethia</u> <u>alba</u> Sanderling

Habitat -- October-November 1964 - Kwajalein Island on runway (2-3 November), Roi-Namur on runway taxi strip area (4 November).

Numbers -- October-November 1964 - Kwajalein Island 1 seen 2 and 3 November and collected; Roi-Namur 2 observed (4 November).

Status -- Migrant.

Specimen Records -- Other - none; POBSP - two (Table 22). This is a new species and specimen record for Kwajalein Atoll.

21) <u>Erolia</u> <u>acuminata</u> Sharp-tailed Sandpiper

Habitat -- October-November 1964 - around fresh water "pond" area between the runway and taxi strip on Kwajalein.

Numbers -- October-November 1964 - Kwajalein 25, none seen on other islands. One unidentified <u>Erolia</u> sighted on 17 June 1966 at Kwajalein Island probably was of this species.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - nine (Table 22). These observations and collections constitute a new species and specimen record for Kwajalein Atoll.

22) <u>Sterna</u> <u>sumatrana</u> Black-naped Tern

Habitat -- 5 February 1956 - seen flying over the lagoon side of Ebeye (Fosberg, 1966); October-November 1964 - seen flying off eastern tip of Enebuoj; June 1966 - seen flying inside and outside the lagoon, but usually fairly close to islands.

Numbers -- 5 February 1956 - Ebeye 2 (Fosberg, 1966); October-November 1964 - Enebuoj (lagoon area) 3; June 1966 - 15+ feeding outside the lagoon (northern end of atoll) on 15 June, several seen inside the lagoon on 14 and 16 June.

Status -- Resident breeder? No breeding records known. This species probably breeds at Kwajalein Atoll, but due to the large number of islands and the size of the atoll, their nests have not been discovered.

Specimen Records -- None.

23) Sterna lunata Gray-backed Tern

Habitat -- 25-27 July 1960 - "...along the beach at Kwajalein." (Yocom, 1964).

Numbers -- 25-27 July 1960 - "...2 Sooty Terns...or Gray-backed Terns...at Kwajalein." (Yocom, 1964).

Status -- Resident breeder? There is no record of this species breeding at Kwajalein Atoll, however, there is a possibility that it could breed within the atoll.

Specimen Records -- None.

24) Sterna fuscata Sooty Tern

Habitat -- 23 January 1952 - observed on Eniwetak (Fosberg, 1966); 25-27 July 1960 - along the beach at Kwajalein (Yocom, 1964).

Numbers -- 23 January 1952 - "Ted Arnow saw one Sooty Tern on Eniwetak Islet..." (Fosberg, 1966); 25-27 July 1960 - "2 Sooty Terns (Sterna fuscata) or Gray-backed Terns (Sterna lunata)... at Kwajalein [Island]." (Yocom, 1964).

Status -- Resident breeder? This species is not known to breed at Kwajalein, however, there is a possibility it may breed on one of the many unvisited islands in the atoll.

Specimen Records -- None.

25) Thalasseus bergii Crested Tern

Habitat -- 29 February 1952 - observed fishing in the lagoon near the pier (and sewer mouth) on Kwajalein Island (Fosberg, 1966); October-November 1964 - flying over the lagoon side (around the piers) of Kwajalein Island, roosting and flying over the rocky seaward side of Roi-Namur; June 1966 - seen inside the lagoon on 14 June.

Numbers -- 29 February 1952 - Kwajalein Island 6 (Fosberg, 1966); October-November 1964 - Kwajalein 4, Roi-Namur 6; June 1966 - present inside the lagoon on 14 June.

Status -- Resident breeder? No breeding records are known from Kwajalein Atoll, however, it probably breeds on some of the little-visited islands in the atoll.

Specimen Records -- None.

26) *Anous stolidus* Brown Noddy

Habitat -- May 1944 - in flock with *Gygis alba* at Kwajalein going to sea at daybreak and returning by 1600 (Baker, 1951); 1952 - Lojjaiong and Lojjairok - present 15 January, Enebuoj - especially on and over the outer reef flat 19 January, Eniwetak - present 23 January, near Enelapkan on 3 August (Fosberg, 1966); October-November 1964 - Loi flying over and roosting in *Pisonia* trees; June 1966 - observed flying over many islands inside lagoon (14 June), seen feeding outside the atoll just before sunset and returning after sunset to the north part of the atoll (15 June), observed in the lagoon (16 June).

Numbers -- May 1944 - Wallace observed 40+ at Kwajalein (Baker, 1951); 1952 - Lojjaiong and Lojjairok quite plentiful 15 January, Enebuoj many were seen 19 January, Eniwetak few were seen 23 January, one seen near Enelapkan on 3 August (Fosberg, 1966); October-November 1964 - Loi 20, none seen on other islands visited; June 1966 - quite a few seen over the islands and in the lagoon, 2,500 seen feeding outside the lagoon just before sunset and returning to the islands after sunset on 15 June.

Status -- Resident breeder? 15 January 1952 - Lojjaiong and Lojjairok "...one or two were obviously gathering nesting material." (Fosberg, 1966); October-November 1964 - no breeding observed but few islands visited. This species probably breeds on all suitably vegetated islands at Kwajalein Atoll.

Specimen Records -- Other - none; POBSP - three (Table 22). This collection is the first specimen record for this species from Kwajalein Atoll.

27) *Anous tenuirostris* Black Noddy

Habitat -- 1952 - Lojjaiong-flying over lagoon area, Eniwetak-seen nesting high in the *Pisonia grandis* trees 23 January, Kwajalein - flock fishing in the lagoon 27 January-1 February (Fosberg, 1966); October-November 1964 - Kwajalein - flying over seaward beaches and occasionally over the island proper, Roi-Namur - flying over and roosting in *Cocos* and *Pisonia* trees and on beaches, Loi flying and roosting in *Pisonia* trees, lagoon proper, small flocks fishing; June 1966 - over most islands, on 15 June seen feeding outside the lagoon at the north part of the atoll.

Numbers -- 1952 - Lojjaiong 4 seen on 15 January, Eniwetak hundreds seen nesting on 23 January, Kwajalein flock of 2-3 dozen in lagoon from 27 January to 1 February (Fosberg, 1966); October-November 1964 - Kwajalein 10, Roi-Namur 25, Loi 10, Ebeye lagoon 5; June 1966 - quite a few seen over the various islands, 300 observed feeding outside the northern end of the atoll just before sunset on 15 June.

Status -- Resident breeder. 23 January 1952 - hundreds were seen nesting on Eniwetak; October-November 1964 - no breeding activity observed, but all islands not visited; June 1966 - no breeding observed, but few islands visited.

Specimen Records -- Other - none; POBSP - four (Table 22). These skins represent a new specimen record for Kwajalein Atoll.

28) Gygis alba White Tern

Habitat -- May 1944 - in a flock with Anous stolidus (Baker, 1951); 1952 - Lojjaiong - flying over the island 15 January, Enebuoj - nesting 19 January (Fosberg, 1966); 25-27 July 1960 - one seen in the atoll (Yocom, 1964); October-November 1964 - Roi-Namur - flying over and roosting on the tall vegetation, Loi - roosting in Pisonia trees; June 1966 - observed over many islands, feeding outside the northern part of the atoll just before sunset 15 June.

Numbers -- May 1944 - present (Baker, 1951); 15 January 1952 - Lojjaiong - a number were seen flying over, 19 January 1952 - Enebuoj - several flew over, Eniwetak-large numbers present (Fosberg, 1966); 25-27 July 1960 - one seen (Yocom, 1964); October-November 1964 - Roi-Namur 10, Loi 30; July 1966 - quite a few over most islands, 40+ seen outside the northern part of the atoll on 15 June.

Status -- Resident breeder. 19 January 1952 - Eniwetak several young ones present (Fosberg, 1966); October-November 1964 - no evidence of breeding observed, however, all islands not visited; July 1966 - no breeding but few islands visited.

Specimen Records - Other - none; POBSP - one (Table 22). Although White Terns have previously been recorded from Kwajalein Atoll, this is the first specimen record for this species from the atoll.

29) Passer domesticus House Sparrow

Habitat -- October-November 1964 - Kwajalein Island, flying in and around the fuel depot-fueling dock and nursery area.

Numbers -- October-November 1964 - 3 seen at one time but possibly more present, not present on other islands visited.

Status -- Resident breeder? October-November 1964 - no breeding activity observed, but conditions are favorable for this species to breed on Kwajalein Island and some of the other islands in the atoll.

Specimen Records -- None. Due to the area involved, firearms could not be used to collect specimens of this species. Mist

nets were tried, but were unsuccessful in obtaining specimens. This is a new species record for Micronesia (not listed in Baker, 1951). This species is known, however, from Wake Atoll some 600 miles north of Kwajalein Atoll (Marshall, 1957).

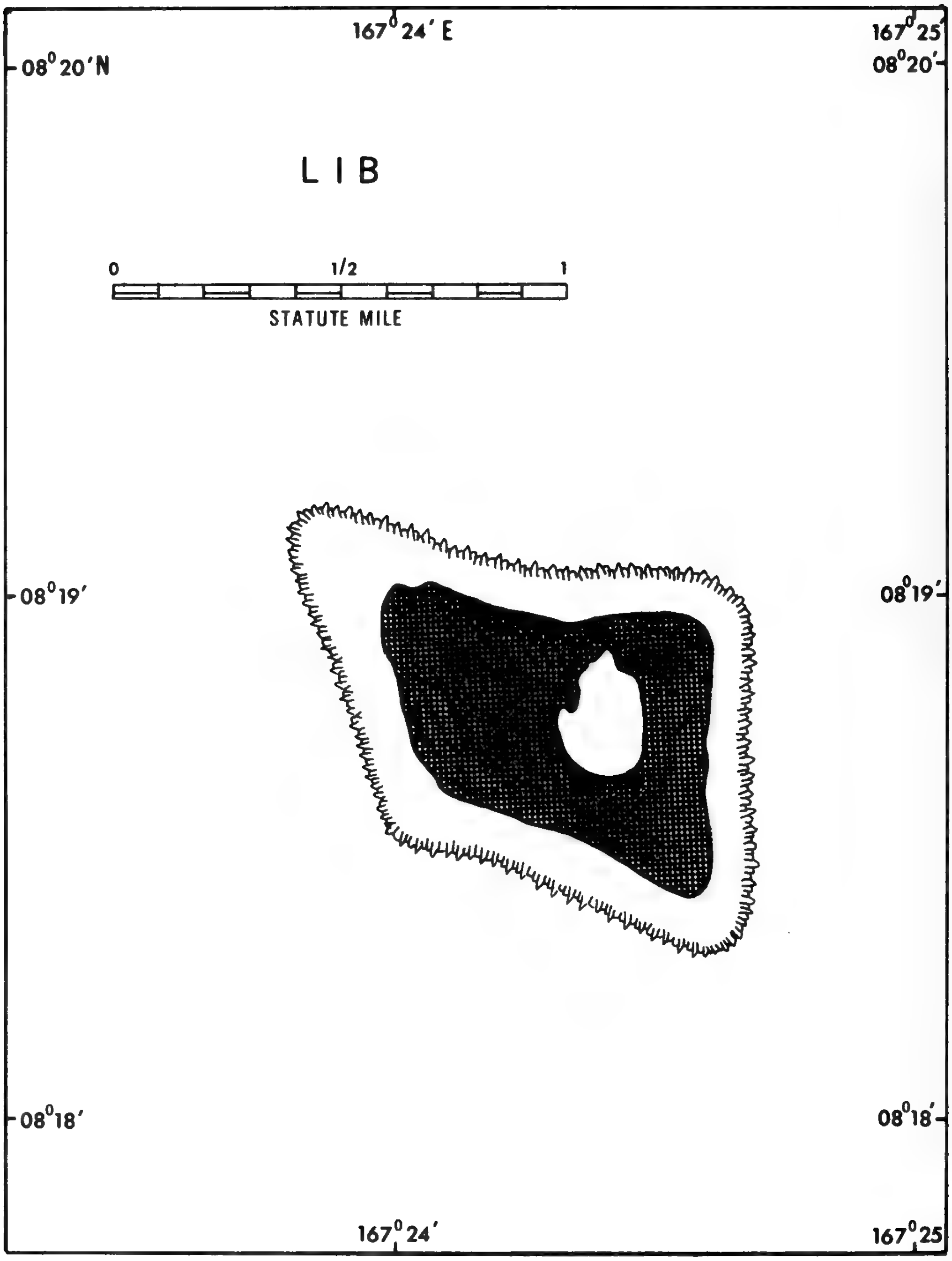
30) Acridotheres tristis Indian Mynah

Habitat -- 11 June 1950 - Kwajalein Island perched on main airport building (Marshall, 1957); 1952 - Kwajalein Island around the military establishment (Fosberg, 1956, 1966); July 1956 - Kwajalein Island in gardens around the nursery eating papayas (Marshall, 1957).

Numbers -- 11 June 1950 - Kwajalein Island 1 (Marshall, 1957); 1952 - Kwajalein Island, introduced and fairly common, several pairs established and very much at home (Fosberg, 1956,1966); July 1956 - Kwajalein Island 6 (Marshall, 1957); 1956,1958, 1960 - not seen (Fosberg, 1966); October-November 1964, July 1966 - none observed.

Status -- Resident breeder, now absent. 1952 - "...pairs were established and very much at home on Kwajalein Islet..." (Fosberg,1966).

Specimen Records -- None.


167°24′ E
167°25′
08°20′N
08°20′
LIB
0
1/2
1
STATUTE MILE
08°19′
08°19′
08°18′
08°18′
167°24′
167°25′

LIB ISLAND

Location: 08°19' N x 167°25' E.

Shape and Size: Triangle-shaped; Tip to tip (east-west) - 0.75 miles; Width - 0.50 miles; No lagoon, but a fresh water pond is located in the center of the island; Total dry land area 0.36 square miles; Number of islands - 1; Height ? feet (Fosberg,1956).

Soil: Unknown, but said to be fertile (Findlay, 1886).

Vegetation: Only Cocos and Pandanus known.

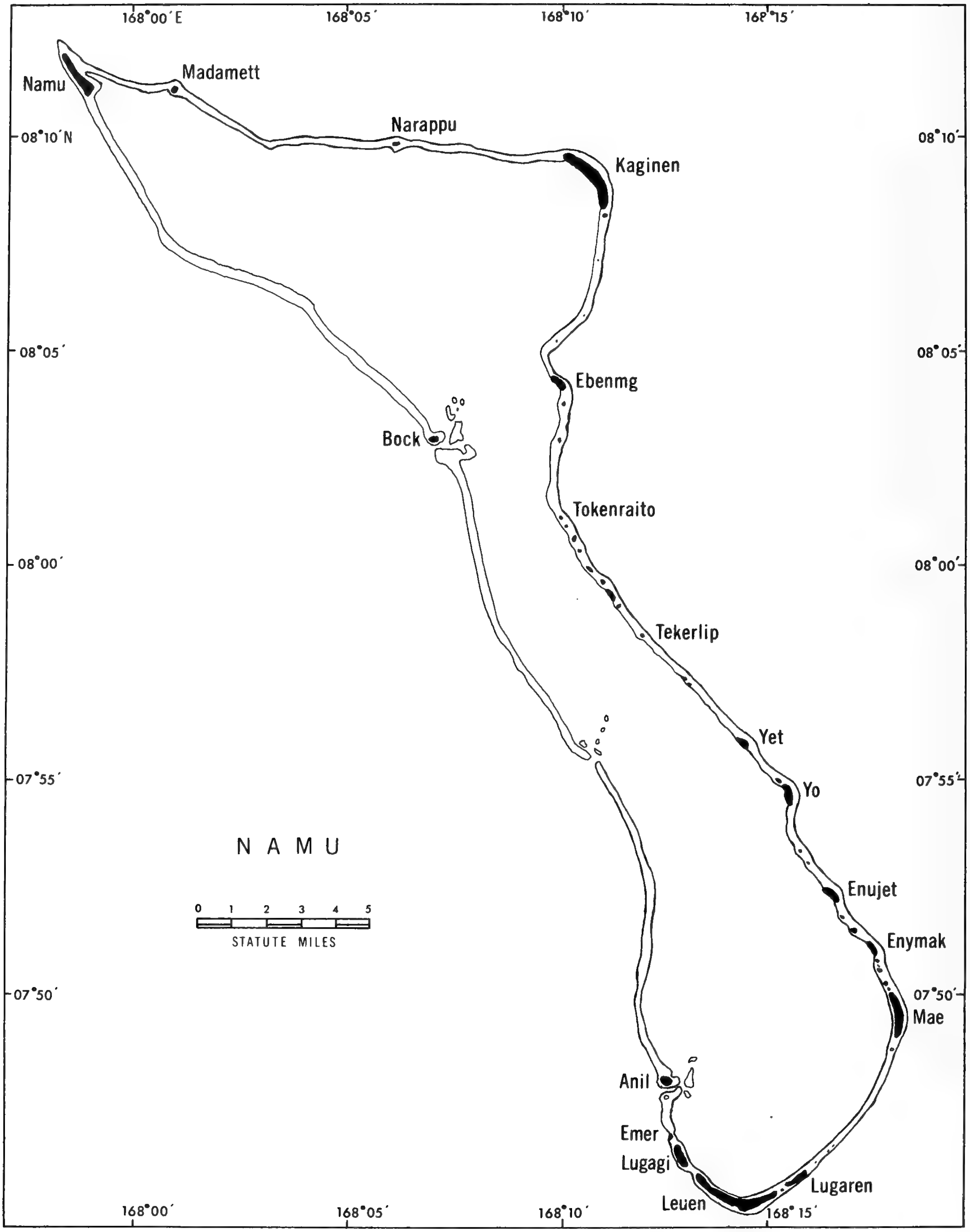
Climate: Wet, about 100-120 inches of rainfall yearly; Mean air temperature - 82°F; Winds - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 23 in 1800's (Findlay, 1886); 84 in 1948 (Freeman, 1951); Present - inhabited, 190 in 1963 (U.S. Department of State, 1965).

Scientific Visits: None.

Avifauna: No bird records exist for Lib Island.

348-415 O-69—12



168°00′E
168°05′
168°10′
168°15′
08°10′N
08°10′
08°05′
08°05′
08°00′
08°00′
07°55′
07°55′
07°50′
07°50′
168°00′
168°05′
168°10′
168°15′
Namu
Madamett
Narappu
Kaginen
Ebenmg
Bock
Tokenraito
Tekerlip
Yet
Yo
Enujet
Enymak
Mae
Anil
Emer
Lugagi
Leuen
Lugaren
N A M U
0 1 2 3 4 5
STATUTE MILES

NAMU ATOLL

Location: 08°00' N x 168°10' E.

Shape and Size: Irregular dumbbell-shaped; Tip to tip (northwest-southeast) - 32 miles; Width (northeast-southwest) - 2 to 7 miles; Total lagoon area - 153.53 square miles; Total dry land area - 2.42 square miles; Number of islands - 51; Height - 11 feet (Fosberg, 1956).

Soil: Beach (lagoon) - mostly sandy with some exposed rock; Interior - sand, some black with humus.

Vegetation: Eighteen known species; most islands planted with Cocos and large breadfruit trees (Wiens, 1957).

Climate: Wet, about 100-120 inches of rainfall yearly; Mean air temperature - 82° F.; Winds - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, 150 in 1800's (Findlay, 1886); 341 in 1948 (Freeman, 1951); Present - inhabited, 684 in 1963 (U. S. Dept. of State, 1965).

Scientific Visits: Japanese expedition - 19 October 1931; Pacific Science Board (H. J. Wiens) - summer 1956.

Avifauna: Six bird species have been recorded from Namu Atoll. All 6 of these are seabirds. One species is definitely known to breed, while the other 5 are potential breeders.

POBSP personnel passed within one mile of the east tip of Namu Atoll during the afternoon of 2 May 1967, while travelling from Ailinginae Atoll to Jabwot Island. Red-footed Booby, Brown Noddy, Black Noddy, and White Tern were observed flying to the atoll.

The 6 species known from Namu Atoll are included in the following checklist. The source material from which this list was compiled includes: (1) Baker, 1951; (2) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (3) Yamashina, 1932; (4) POBSP band recovery; (5) YIZM collection; and (6) POBSP data (offshore). These sources are referred to in the checklist by corresponding numbers and letters. The 3 species marked with an asterisk are new species records for Namu Atoll.

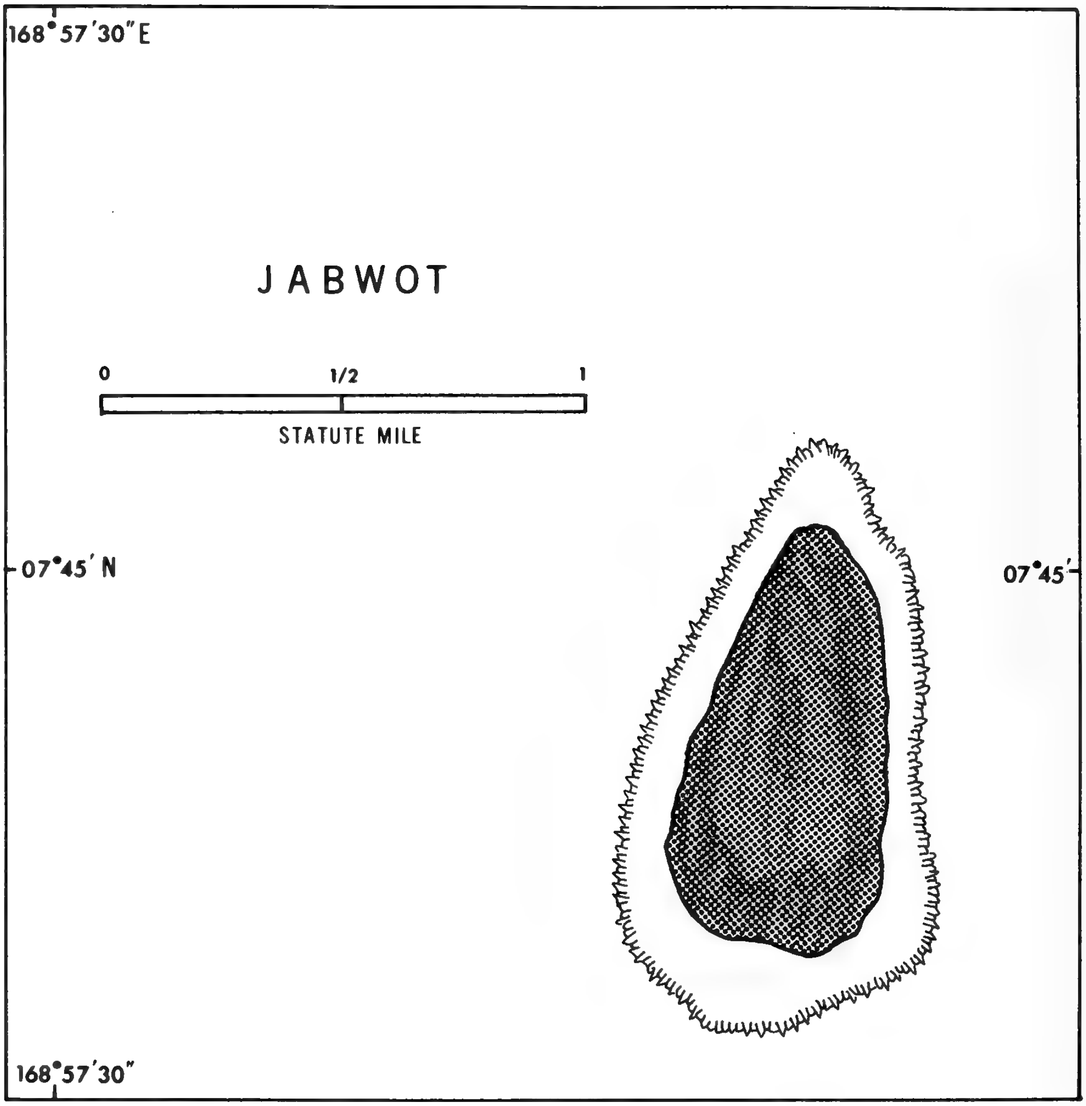
NAMU ATOLL AVIFAUNA CHECKLIST

Species	Status	Source
1) *Sula sula**	Resident breeder ?	4, 6
2) *Fregata minor*	Resident breeder ?	1, 2ab, 5
3) *Sterna sumatrana*	Resident breeder ?	1, 2ab, 5
4) *Anous stolidus**	Resident breeder ?	6
5) *Anous tenuirostris*	Resident breeder, November	1, 3, 6
6) *Gygis alba**	Resident breeder ?	6

Bird specimens collected from Namu Atoll include seven specimens of two species.

Table 23. Bird Specimens collected from Namu Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Fregata minor	YIZM	♂	A	Namu I	10-19-31	Skin	H. Orii
" "	YIZM	♂	A	"	"	Lost	"
" "	YIZM	♀	Juv	"	"	Skin	"
Sterna sumatrana	YIZM	♂	Juv	"	"	"	"
" "	YIZM	♂	A	"	"	"	"
" "	YIZM	♂	I	"	"	-	-
" "	MCZ	♂	-	"	"	Skin	-



168°57'30"E
JABWOT
0
1/2
1
STATUTE MILE
07°45' N
07°45'
168°57'30"

JABWOT ISLAND

Location: 07°47' N x 168°59' E.

Shape and Size: Oval; Tip to tip (northwest-southeast) - 0.75 miles; Width - 0.25 mile; No lagoon; Total dry land area - 0.22 square miles; Number of islands - 1; Height - 30± feet (Fosberg, 1956).

Soil: Beach (windward or northeast) - mostly solid rock, some sand in spots; Beach (leeward or southwest) - sandy with cobblestone areas toward each end; Interior - sandy on beach crest, dark humus in wooded areas.

Vegetation: Number of species unknown; many tall *Cocos* throughout the island, some *Pandanus* and *Artocarpus* around village; some scattered *Pisonia* and fern; heavy undergrowth in places.

Climate: Wet, about 100-120 inches of rainfall yearly; Mean air temperature - 82° F.; Wind - prevailing from east to north (Fosberg, 1956).

Human Population: Past - inhabited, few in 1800's (Findlay, 1886); none in 1948 (Freeman, 1951); Present - inhabited, 92 in 1963 (U. S. Dept. of State, 1965); 90+ in 1967 (POBSP).

Scientific Visits: POBSP - 3 May 1967.

Avifauna: Nine bird species are known from Jabwot Island. These include 3 seabirds, 4 shorebirds, 1 heron, and 1 domestic fowl. One of these species is a known breeder, 4 others are possible breeders, and 4 are migrants.

Nine species are listed in the following checklist, which was derived solely from data collected by POBSP personnel in 1967 as indicated under sources by the number 1. All nine species are new species records for Jabwot Island; these are marked by a single asterisk. The single species marked by double asterisks is a new island breeding record.

Jabwot Island Avifauna Checklist

Species	Status	Source
1) *Fregata minor**	Resident breeder ?	1
2) *Egretta sacra**	Resident breeder ?	1
3) *Gallus gallus* *	Introduced breeder**	1
4) *Pluvialis dominica**	Migrant	1
5) *Numenius tahitiensis**	Migrant	1
6) *Heteroscelus incanum**	Migrant	1
7) *Arenaria interpres**	Migrant	1
8) *Anous stolidus* *	Resident breeder ?	1
9) *Gygis alba**	Resident breeder ?	1

POBSP personnel have collected four specimens of three species (Table 24). All three of these species are specimen records of species not previously known from Jabwot Island. No other specimens are known from this island.

Table 24. Bird specimens collected by POBSP from Jabwot Island.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Pluvialis dominica	USNM 543387	♀	A	Jawbot	5-3-67	Skin	Amerson
Numenius tahitiensis	" 543455	♀	-	"	"	"	"
Anous stolidus	" 543412	♀	A	"	"	"	"
" "	" 543413	♂	A	"	"	"	"

Species Accounts

1) Fregata minor — Great Frigatebird

Habitat -- May 1967 - flying high above the island.

Numbers -- May 1967 - one adult female seen.

Status -- Resident breeder? May 1967 - No evidence of breeding, but may possibly breed on Jabwot Island.

Specimen Records -- None. This observation is a new species sight record for Jabwot Island.

2) Egretta sacra — Reef Heron

Habitat -- May 1967 - on the rocky north beach.

Numbers -- May 1967 - one observed.

Status -- Resident breeder? May 1967 - no evidence of breeding. This species may, however, breed on the undisturbed portions of the island.

Specimen Records -- None. This observation represents a new species sight record for the island.

3) Gallus gallus — Domestic Chicken

Habitat -- May 1967 - present around the main village, around most other occupied houses, as well as scattered throughout the thick vegetated portions of the island.

Numbers -- May 1967 - 50 estimated.

Status -- Introduced breeder. May 1967 - breeding, small chicks present. This is a new breeding record for the island.

Specimen Records -- None. This observation constitutes a new species sight record for Jabwot.

4) <u>Pluvialis</u> <u>dominica</u> Golden Plover

Habitat -- May 1967 - on the sandy portion of the northeast beach.

Numbers -- May 1967 - two seen.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - one (Table 24). This represents a new species and specimen record for Jabwot Island.

5) <u>Numenius</u> <u>tahitiensis</u> Bristle-thighed Curlew

Habitat -- May 1967 - on sandy beach areas.

Numbers -- May 1967 - two seen.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - one (Table 24).This represents a new species and specimen record for Jabwot Island.

6) <u>Heteroscelus</u> <u>incanum</u> Wandering Tattler

Habitat -- May 1967 - on rocky and sandy beach areas.

Numbers -- May 1967 - two observed.

Status -- Migrant.

Specimen Records -- None. This observation is a new species sight record for the island.

7) <u>Arenaria</u> <u>interpres</u> Ruddy Turnstone

Habitat -- May 1967 - observed on sandy and rocky beach areas.

Numbers -- May 1967 - six recorded.

Status -- Migrant.

Specimen Records -- None. This observation is a new species sight record for the island.

8) Anous stolidus — Brown Noddy

Habitat -- May 1967 - flying above the island; occasional flights to and from the ocean, especially on the windward (north side); roosting and possibly nesting in the coconut palm groves.

Numbers -- May 1967 - 25 adults estimated.

Status -- Resident breeder? May 1967 - no nests seen, but probably nests in palm trees.

Scientific Records -- Other - none. POBSP - two (Table 24). This constitutes a new species and specimen record for Jabwot Island.

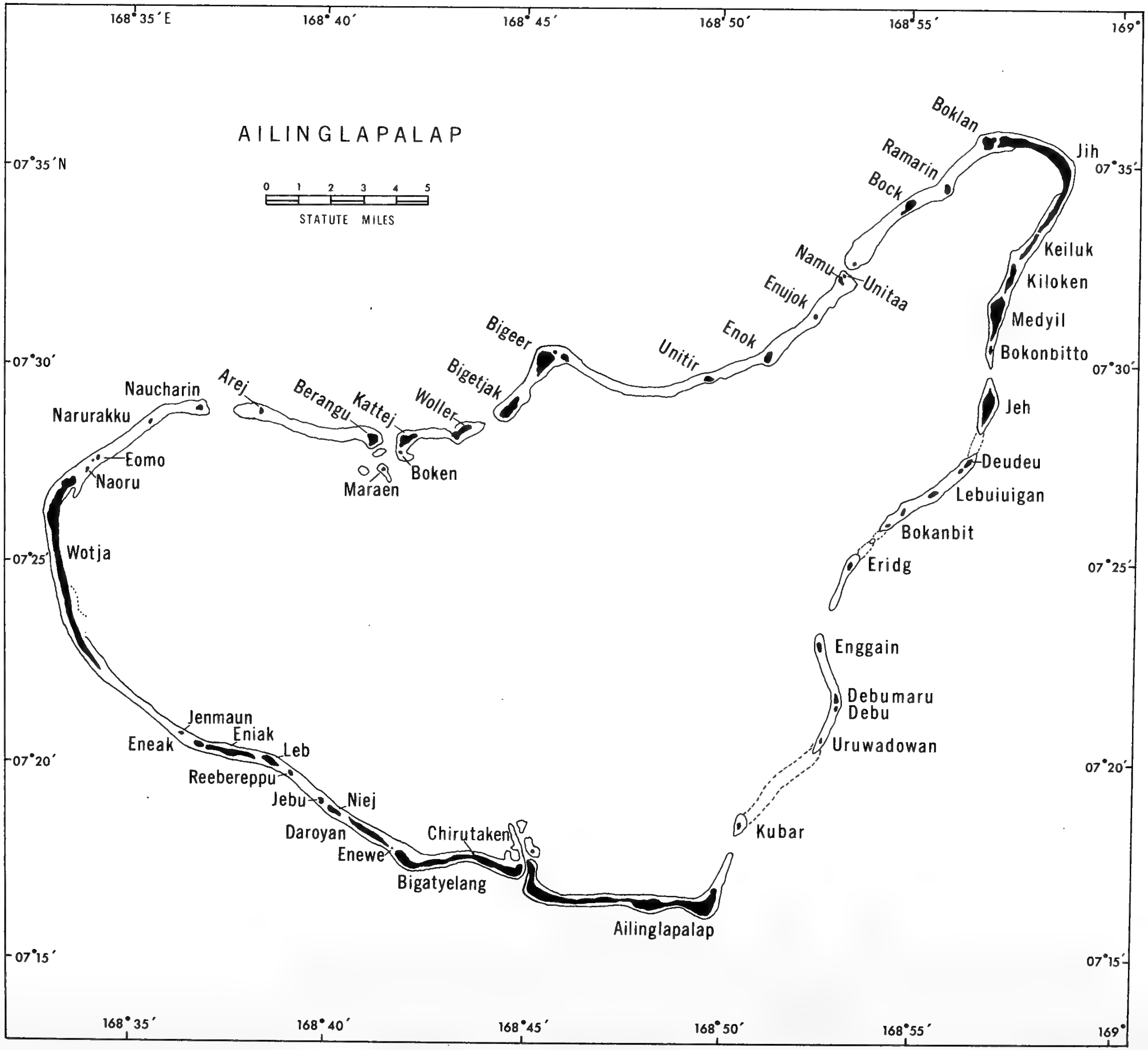
9) Gygis alba — White Tern

Habitat -- May 1967 - flying above the island, as well as to and from the ocean.

Numbers -- May 1967 - 50 estimated.

Status -- Resident breeder? May 1967 - No nests observed, however, this species probably nests on Jabwot Island.

Specimen Records -- None. This observation represents a new species sight record for the island.


AILINGLAPALAP
0 1 2 3 4 5
STATUTE MILES
168° 35′ E
168° 40′
168° 45′
168° 50′
168° 55′
169°
07° 35′ N
07° 30′
07° 25′
07° 20′
07° 15′
Boklan
Ramarin
Bock
Jih
Keiluk
Kiloken
Medyil
Bokonbitto
Jeh
Deudeu
Lebuiuigan
Bokanbit
Eridg
Enggain
Debumaru
Debu
Uruwadowan
Kubar
Namu
Unitaa
Enujok
Enok
Unitir
Bigeer
Bigetjak
Woller
Kattej
Berangu
Arej
Boken
Maraen
Naucharin
Narurakku
Eomo
Naoru
Wotja
Jenmaun
Eniak
Eneak
Leb
Reebereppu
Jebu
Niej
Daroyan
Enewe
Chirutaken
Bigatyelang
Ailinglapalap

AILINGLAPALAP ATOLL

Location: 07°23' N x 168°46' E.

Shape and Size: Irregular triangle-shaped; Tip (northeast) to base (southwest) - 27 miles; Width (southwest base) - 19 miles; Total lagoon area - 289.69 square miles; Total dry land area - 5.67 square miles; Number of islands - 52; Height - 5 to 25 feet (Fosberg, 1956).

Soil: Beach (Wotja, windward lagoon side) - stratified beachrock; Interior - sandy soil (Wiens, 1957).

Vegetation: Twenty-nine known species; Wotja, relatively luxuriant vegetation, *Cocos* and other food-type plants; Mangrove swamp on longest island (Wiens, 1957).

Climate: Wet, about 100-120 inches of rainfall yearly; Mean air temperature - 82° F.; Wind - prevailing from north and east (Fosberg, 1956; U.S. Navy, 1964).

Human Population: Past - inhabited (Findlay, 1886); 705 in 1948 (Freeman, 1951); Present - inhabited, 1,183 in 1963 (U.S. Dept. of State, 1965).

Scientific Visits: Japanese expedition - 18, 21, 24 October 1931; Pacific Science Board (H. J. Wiens) - summer 1956.

Avifauna: Four species of birds are known from Ailinglapalap Atoll. These species include a seabird, a shorebird, a pigeon, and a cuckoo. The seabird and pigeon species are potential breeders, but neither are known to breed on the atoll.

An annotated checklist of the four bird species from Ailinglapalap follows. The source material for this list includes: (1) Baker, 1951); (2) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (3) Peters, 1937; (4) Amadon, 1943; (5) Mayr, 1945; (6) POBSP band recovery; and (7) YIZM collection. These sources are referred to in the checklist by the corresponding numbers and letters. The species marked with an asterisk is a new record for the atoll.

AILINGLAPALAP ATOLL AVIFAUNA CHECKLIST

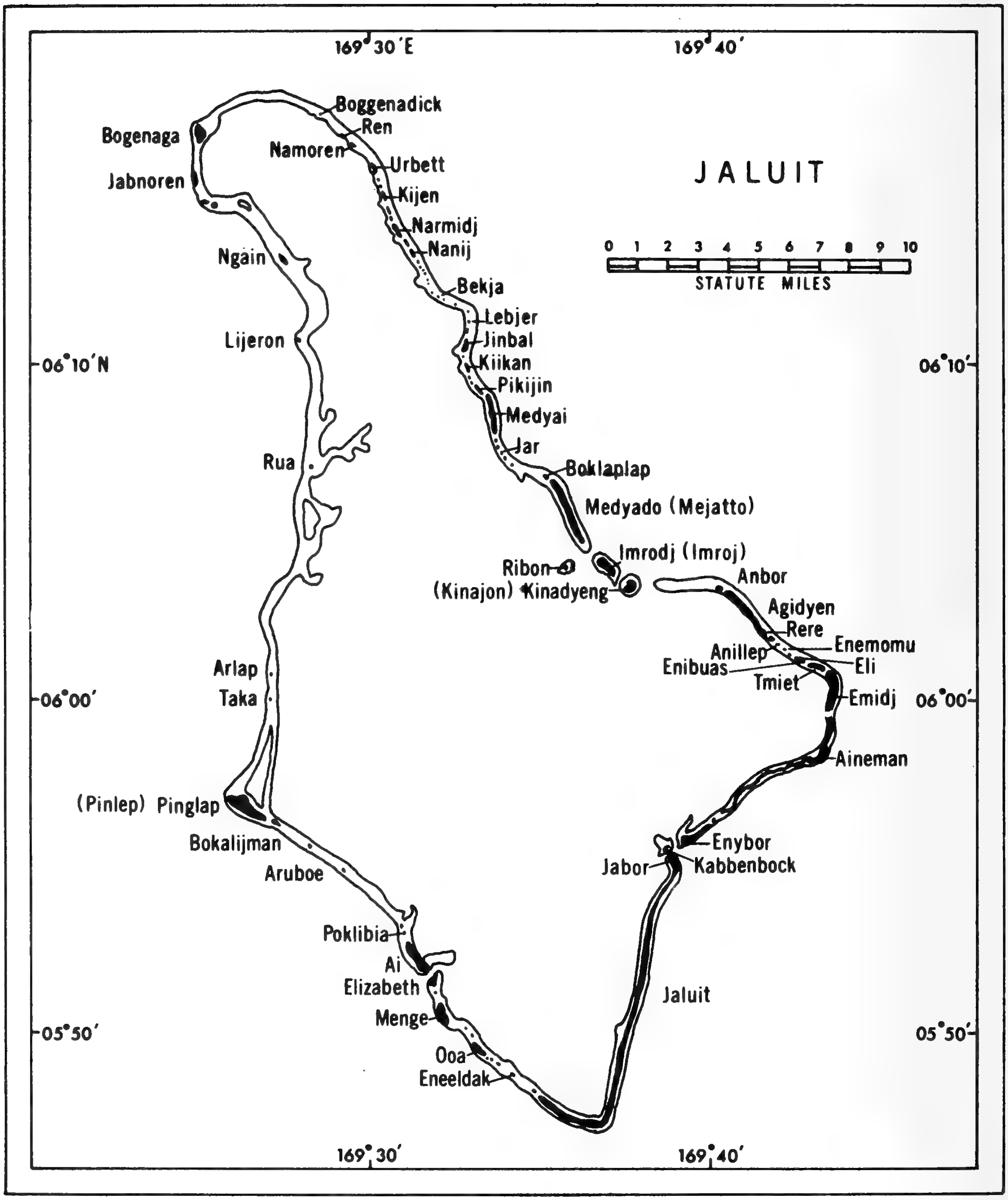
Species	Status	Source
1) *Arenaria interpres**	Migrant	6
2) *Anous tenuirostris*	Resident breeder ?	1, 2ab, 7
3) *Ducula oceanica*	Resident breeder ?	1, 2ab, 3, 4, 5, 7
4) *Urodynamis taitensis*	Migrant	1, 2ab, 7

Bird specimens collected on Ailinglapalap Atoll include 16 specimens of 3 species. These specimens are all in the YIZM collection

Table 25. Specimens collected from Ailinglapalap Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anous tenuirostris	YIZM	♂	N	Iringlove *	10-21-31	Skin	H. Orii
"	YIZM	♂	Juv	"	10-24-31	"	"
"	YIZM	♂	Juv	"	"	"	"
"	YIZM	♂	Juv	"	"	"	"
"	YIZM	♀	Juv	"	"	"	"
"	YIZM	♂	A	"	"	"	"
Ducula oceanica oceanica	YIZM	♂	A	"	10-18-31	"	"
"	YIZM	♂	A	"	"	Lost	"
"	YIZM	♂	Juv	"	"	"	"
"	YIZM	♂	A	"	10-24-31	Skin	"
"	YIZM	♂	A	"	"	Lost	"
"	YIZM	♂	A	"	"	"	"
"	YIZM	♂	A	"	"	Skin	"
"	YIZM	♂	A	"	"	"	"
"	YIZM	♂	A	"	"	"	"
Urodynamis taitensis	YIZM	♂	A	"	"	"	"

*Probably Ailinglapalap Island



169° 30′ E
169° 40′
JALUIT
0 1 2 3 4 5 6 7 8 9 10
STATUTE MILES
Boggenadick
Ren
Bogenaga
Namoren
Urbett
Jabnoren
Kijen
Narmidj
Nanij
Ngain
Bekja
Lebjer
Jinbal
Lijeron
Kiikan
06°10′N
06°10′
Pikijin
Medyai
Jar
Rua
Boklaplap
Medyado (Mejatto)
Imrodj (Imroj)
Ribon
(Kinajon) Kinadyeng
Anbor
Agidyen
Rere
Enemomu
Anillep
Eli
Enibuas
Tmiet
Arlap
Emidj
Taka
06°00′
06°00′
Aineman
(Pinlep) Pinglap
Bokalijman
Enybor
Jabor
Kabbenbock
Aruboe
Poklibia
Ai
Elizabeth
Jaluit
Menge
05°50′
05°50′
Ooa
Eneeldak
169° 30′
169° 40′

JALUIT ATOLL

Location: 06°00' N x 169°35' E.

Shape and Size: Irregular diamond-shaped; North to south - 30 miles; East to west - 15 miles; Total lagoon area -266.31 square miles; Total dry land area - 4.38 square miles; Number of islands - 84; Height 15-20 feet (Fosberg in Blumenstock, 1961).

Soil: Principal soils include five types: (1) Shioya Series, (2) Arno Atoll Series, (3) Jemo Series, (4) mangrove peat, and (5) stony and very stony complex (Fosberg in Blumenstock, 1961); Beaches - sandy, rocky, or cobblestone areas.

Vegetation: Seventy-seven species; primary genera: *Cocos*, *Pandanus*, *Pisonia*, *Sonneratia*; large number of exotics present (Fosberg in Blumenstock, 1961).

Climate: Very wet, between 170-190 inches of rainfall annually; Air temperature ranges 68° F. to 94° F.; Northeast tradewinds; Typhoon OPHELIA hit Jaluit Atoll on 7 January 1958 inflicting severe damage (Blumenstock, 1958, 1961).

Human Population: Past - inhabited, headquarters of German and Japanese administrations in the Marshalls; Total population - 950 in 1949 (Mackenzie in Blumenstock, 1961);present-inhabited, 1,127 in 1964(U.S. Dept. of State,1965).

Scientific Visits: Otto Finsch - 21 August-15 November 1879; Japanese Expedition - September-November 1931 and 3 January 1933; Pacific Science Board - 24 April-2 May 1958 and 20-29 October 1960; POBSP 10-21 November 1964.

Avifauna: Thirty-three bird species are known from Jaluit Atoll. These include 13 seabirds, 11 shorebirds, 5 ducks, 1 heron, 1 domestic fowl, 1 pigeon, and 1 cuckoo. Eleven of these species are known breeders , 4 others are possible breeders, 9 are migrants,6 are accidentals, and 3 are common visitors.

Another species, *Sula dactylatra*, was listed by Baker (1951) from Jaluit Atoll. He undoubtedly based this listing upon Finsch (1880a), who observed "... one Booby (*Sula cyanops*)" on 13 August 1879 while on a trip from Honolulu, Hawaii, to Jaluit Atoll. Since his ship left Honolulu on 29 July, passed Mili Atoll on 16 August, and arrived at Jaluit on 21 August, the sighting of the Blue-faced Booby on 13 August was east of Mili Atoll and at least 350 miles away from Jaluit Atoll. Therefore, this listing should not be considered valid.

Jaluit Atoll is the only locality in the Marshall and Gilbert Islands from which *Anas penelope*, *Aythya valisineria*, *Charadrius semipalmatus*, *Charadrius mongolus* and *Sterna hirundo nigripennis* have been recorded.

348-415 O-69—13

Thirty-three species are listed in the following checklist, which was derived from various sources: (1) POBSP, 1964; (2) Gressitt in Blumenstock, 1961; (3) YIZM collection; (4) Baker, 1951; (5) Finsch, (a) 1880a, (b) 1880b, (c) 1880c, (d) 1880d, (e) 1884; (6) Wiens, 1957; (7) Momiyama, 1922; (8) Reichenow, 1901; (9) Schnee, 1901; (10) Phillips, 1923; (11) Wiglesworth, 1891; (12) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (13) Townsend and Wetmore, 1919; (14) Bent, 1929; (15) Kuroda, 1934; (16) Takataukasa and Yamashina, 1932; (17) Peters, 1937; (18) Amadon, 1943; (19) Mayr, 1945; and (20) Bogert, 1937. These sources are referred to in the checklist by the corresponding numbers and letters. The six species marked by a single asterisk are new species records for Jaluit Atoll; the three species marked by double asterisks are new atoll breeding records.

Jaluit Atoll Avifauna Checklist

Species	Status	Source
1) Puffinus pacificus	Resident breeder ?	2
2) Phaethon lepturus	Resident breeder**	1, 2
3) Sula sula*	Resident breeder**	1
4) Sula leucogaster	Resident breeder**	1, 2
5) Fregata minor	Resident breeder ?	1, 2
6) Fregata ariel*	Resident breeder ?	1
7) Egretta sacra	Resident breeder ?	1,2,3,4,5be,6,7
8) Anas crecca	Accidental	4, 8, 9, 10
9) Anas penelope	Visitor	4,5ae,7,10,11,12b
10) Anas acuta	Visitor	4, 8, 9, 10
11) Aythya valisineria	Visitor	4, 8, 9
12) Anatidae sp*	Accidental ?	1
13) Gallus gallus*	Introduced breeder	1
14) Pluvialis dominica	Migrant	1, 2, 4, 5be
15) Charadrius semipalmatus	Migrant	4, 5c, 7, 11
16) Charadrius mongolus	Accidental	3, 4, 12abc
17) Charadriinae sp.*	Accidental	1
18) Numenius phaeopus	Migrant	1,2,3,4,12abc
19) Numenius tahitiensis	Migrant	1,4,5ae,7,12abc,14
20) Totanus melanoleucus	Vagrant	4, 12b, 15
21) Heteroscelus incanum	Migrant	1,2,3,4,5be,7,12abc
22) Arenaria interpres	Migrant	1,2,3,4,5be,7,12abc
23) Crocethia alba	Migrant	5bce, 7, 11, 12abc
24) Erolia acuminata	Migrant	3, 4, 12abc
25) Sterna hirundo nigripennis*	Accidental	1
26) Sterna sumatrana	Resident breeder	1,2,3,4,5bd,7,11,12abc
27) Sterna fuscata	Resident breeder	1, 6
28) Thalasseus bergii	Resident breeder	1,2,3,4,5ce,12abc
29) Anous stolidus	Resident breeder	1,2,3,4,5e,12abc
30) Anous tenuirostris	Resident breeder	1,2,3,4,5be,6,7,12abc
31) Gygis alba	Resident breeder	1,2,3,4,5b, 6, 12abc
32) Ducula oceanica	Resident breeder	2,3,4,5bce,7,12ab,16, 17,18,19
33) Urodynamis taitensis	Migrant	2,3,4,5bcde,7,11,12ab, 20

POBSP personnel have collected 42 specimens of 13 species (Table 26). Of these 13 species, 3 are specimen records of species not previously known from the atoll, and 3 represent the first specimen confirmation of species previously known only from sight records. Forty-four specimens of 13 species collected at Jaluit Atoll are located in the Yamashina Institute of Zoology and Ornithology Museum, Tokyo, Japan (Table 27).

Table 26. Bird specimens collected by POBSP from Jaluit Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Sula sula	USNM 494869	♀	--	Lijeron	11-11-64	Skin	Huber
"	" 494870	♂	-	"	"	"	"
"	" 494871	♂	-	"	"	"	"
"	" 494872	♀	-	"	"	"	"
"	" 494879	♀	-	"	"	"	"
"	" 494880	♂	-	"	"	"	"
"	" 494881	♂	-	"	"	"	"
"	" 494882	♂	-	"	"	"	"
"	" 494883	♂	-	"	"	"	"
"	" 494884	♂	-	"	"	"	"
Sula leucogaster	" 494925	♂	-	"	"	"	Amerman
Fregata minor	" 494876	♂	-	"	"	"	"
Fregata ariel	" 494873	♂	-	"	"	"	Huber
Egretta sacra	" 494857	♀	-	Enybor	10-10-64	"	Clapp
"	" 494858	♂	-	"	"	"	"
"	" 494859	♂	-	Kabbenbock	"	"	Wislocki
Pluvialis dominica	" 494753	♀	-	Jaliut I	11-11-64	"	Lehner
"	" 502904	-	A	"	"	Alco.	"
Sterna hirundo nigripennis	" 494473	?	A	Enybor	11-10-64	Skin	Clapp
Sterna sumatrana	" 494598	?	Imm	"	11-12-64	"	Amerson
"	" 494599	?	Imm	"	"	"	"
"	" 494600	♂	A	"	"	"	"
Sterna fuscata	" 494717	♀	-	Lijeron	11-11-64	"	"
"	" 494718	♀	-	"	"	"	"
"	" 494719	♂	-	"	"	"	"
Thalasseus bergii	" 494731	♀	A	Kabbenbock	11-10-64	"	Wislocki
"	" 494732	♀	A	Lijeron	11-11-64	"	native
"	" 494733	♂	nest.	"	"	"	Wislocki
Anous stolidus	" 494666	♂	-	Enybor	11-10-64	"	Clapp
"	" 494667	♂	-	"	"	"	"
"	" 494668	♂	-	"	"	"	"
"	" 494669	♂	-	Jaluit I	11-11-64	"	Lehner
"	" 494670	♀	-	Enybor	11-12-64	"	Amerson
Anous tenuirostris	" 494551	♂	A	Lijeron	11-11-64	"	Wislocki
"	" 494552	♂	Imm	"	"	"	Amerman
"	" 494553	♂	Imm	"	"	"	Huber
"	" 494554	?	Imm	"	"	"	"
"	" 494555	♂	-	Enybor	11-12-64	"	Amerson
Gygis alba	" 494633	♀	-	"	11-10-64	"	Clapp
"	" 494634	♂	-	Jaluit I	11-11-64	"	Lehner
"	" 494635	♂	-	Lijeron	"	"	Wislocki
"	" 494636	♀	-	"	"	"	"

Table 27. Bird specimens collected by other expeditions from Jaluit Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Egretta sacra	YIZM	♂	-	Jabole*	10-4-31	Skin	H. Orii
"	"	♂	-	Jaluit I	10-9-31	Lost	"
"	"	♂	Juv	"	10-10-31	Skin	"
"	"	♀	-	Jabole*	10-4-31	"	"
"	"	♀	-	"	11-1-31	Lost	"
"	"	♀	-	Jaluit I	"	"	"
Charadrius mongolus	"	♂	-	"	10-9-31	"	"
"	"	♀	-	"	"	Skin	"
Numenius phaeopus	"	♂	-	"	10-10-31	"	"
"	"	♂	-	"	10-12-31	"	"
Totanus melanoleucus	"	♂	A	"	05-12-32	"	"
Heteroscelus incanum	"	♂	-	"	11-2-31	Lost	"
"	"	♂	-	"	"	"	"
"	"	♀	I	"	11-4-31	"	"
"	"	♂	I	"	"	Skin	"
Arenaria interpres	"	♂	-	"	10-2-32	Lost	"
"	USNM 212216	♂	-	"	01-10-00	Skin	Townsend
Erolia acuminata	YIZM	♂	-	"	10-30-31	"	H. Orii
"	"	♂	-	"	10-31-31	Lost	"
Sterna sumatrana	"	♂	A	"	10-12-31	Skin	"
"	"	♂	Juv	"	"	"	"
"	"	♂	Juv	"	"	"	"
"	"	♀	Juv	"	"	"	"
"	"	♀	Juv	"	"	"	"
Thalasseus bergii	"	♀	A	"	10-9-31	"	"
Anous stolidus	"	♂	A	"	11-4-31	-	-
"	"	♂	A	"	11-1-31	Skin	H. Orii
Anous tenuirostris	"	♂	A	"	10-4-31	"	"
"	"	♂	A	"	"	"	"
"	"	♂	A	"	10-9-31	"	"
"	"	♂	-	"	"	"	"
"	"	♂	A	"	11-1-31	"	"
"	"	♀	A	"	09-4-31	"	"
"	"	-	-	"	11-1-31	"	"
"	"	-	-	"	"	"	"
Gygis alba	"	♀	A	"	10-10-31	"	"
"	"	♀	Juv	"	11-2-31	"	"
"	"	♂	A	"	10-10-31	"	"
"	"	♂	A	"	11-2-31	"	"
Ducula oceanica oceanica	"	♂	A	"	10-10-31	Lost	"
"	"	♂	Juv	"	10-30-31	"	"
"	"	♂	A	"	10-9-31	Skin	"
"	"	♂	-	"	"	"	"
"	"	♀	-	"	"	Lost	"
"	"	♀	A	"	"	Skin	"
Urodynamis taitensis	"	♀	A	"	01-3-33	"	S. Kawakami

*Probably Jaluit or Jabor

Species Account

1) Puffinus pacificus Wedge-tailed Shearwater

Habitat--April-May 1958-observed on Jabor Islet (Gressitt in Blumenstock, 1961). [Note: Dr. F. R. Fosberg (personal communication, November 1966) thought that this species was seen offshore].

Numbers -- April - May 1958 - present on Jabor Islet (Gressitt in Blumenstock, 1961).

Status -- Resident breeder? April - May 1958, not breeding (Gressitt in Blumenstock, 1961).

Specimen Records -- None.

2) Phaethon lepturus White-tailed Tropicbird

Habitat -- April - May 1958 - present on Pinlep (Gressitt in Blumenstock, 1961); November 1964 - not seen on the atoll by POBSP personnel; natives said they were present on some of the islands and nested in tree holes of Pisonia trees.

Numbers -- April - May 1958 - present (Gressitt in Blumenstock, 1961); November 1964 - few present.

Status -- Resident breeder. April - May 1958 - no breeding data (Gressitt in Blumenstock,1961); November 1964 - one reported by a native as nesting. This is a new breeding record.

Specimen Records -- None.

3) Sula sula Red-footed Booby

Habitat -- November 1964 - Lijeron, roosting and nesting in tall Pisonia trees (roosting population arrived just prior to sunset).

Numbers -- November 1964 - Lijeron, approximately 1,500 roosting (majority subadult).

Status -- Resident breeder. November 1964 - five nests with eggs in tops of tall Pisonia trees on Lijeron. This is a new breeding record.

Specimen Records -- Other - none; POBSP - ten (Table 26). This is a new species and specimen record.

4) Sula leucogaster Brown Booby

Habitat -- Baker (1951) lists the range of this species as "... Marshall Islands - Jaluit ..." and based this on Finsch's (1880a)

observation of "... a Sula (uniform brown; certainly S. fusca)" on 31 July 1879 and "one Sula fusca" on 15 August. [Note: These sightings were made by Finsch (1880a) while on a ship which left Honolulu, Hawaii, on 29 July, passed Mili Atoll on 16 August, and arrived at Jaluit Atoll on 21 August. Thus the first sighting was made just after leaving Honolulu and the second sighting was made near Mili Atoll, 350 miles east of Jaluit.] The listing by Baker should be considered invalid; April - May 1958 - seen on Lijeron (Gressitt in Blumenstock, 1961); November 1964-Lijeron in palm trees at night, Jaluit Island 4 or 5 immatures being raised as pets.

Numbers -- April - May 1958 - Lijeron large numbers seen (Gressitt in Blumenstock); November 1964, Lijeron 15 adults seen, Jaluit Island 4 or 5 present.

Status -- Resident breeder. November 1964 - no active nests seen, however, 4 or 5 flying immatures were being kept on Jaluit Island as pets by several natives. These had been raised from 20 nestlings brought from another island in the atoll. Although the pet Brown Boobies are fed by their owners, they also feed at sea by themselves and return home afterwards. This is considered a new breeding record.

Specimen Records -- Other - none; POBSP - one (Table 26). This is a new specimen record for Jaluit Atoll.

5) Fregata minor — Great Frigatebird

Habitat -- April - May 1958 - present on Imrodj and Lijeron (Gressitt in Blumenstock, 1961); November 1964 - Lijeron, (diurnal) flying over island and (nocturnal) roosting in Pemphis trees on north end of island.

Numbers -- April - May 1958 - Lijeron present in large numbers (Gressitt in Blumenstock, 1961); November 1964 - Lijeron estimated population 50+.

Status -- Resident breeder? November 1964 - Lijeron no evidence of breeding, but this species may breed on Jaluit Atoll during another part of the year.

Specimen Records-- Other - none; POBSP - one (Table 26). This is a new specimen record for Jaluit Atoll.

6) Fregata ariel — Lesser Frigatebird

Habitat -- November 1964 - Lijeron flying overhead at dusk with Fregata minor and probably roosts with F. minor in Pemphis trees.

Numbers -- November 1964 - Lijeron 3 or 4.

Status -- Resident breeder? November 1964 - no evidence of breeding, however, there is a possibility this species could breed on Jaluit Atoll.

Specimen Records -- Other - none; POBSP - one (Table 26). This is a new species and specimen record for the Marshall Islands.

7) Egretta sacra Reef Heron

Habitat -- September 1879 - along the beach (Finsch, 1880b); 1955 - 1956 - Enybor Island flying overhead (Wiens, 1957); November 1964 - on sandy and rocky beaches of Enybor, Kabbenbock, Jaluit, Majurirek (Elizabeth), and Lijeron.

Numbers -- September 1879 - a few examples (Finsch, 1880b), present (Momiyama, 1922; Baker, 1951; Gressitt in Blumenstock, 1961); November 1964 - Enybor Island 6, Kabbenbock 4-6, Jaluit 2-3, Elizabeth few, Lijeron 2.

Status -- Resident breeder? Finsch (1884) lists this species under breeding birds but does not give details; November 1964 - not observed breeding, although it is a possibility.

Specimen Records -- Other - six (Table 27); Finsch (1884) reported a young male from Jaluit collected in September 1879 (1880b), but its present deposition is unknown; POBSP - three (Table 26).

8) Anas crecca Green-winged Teal

Habitat -- 1899 present in the atoll (Reichenow, 1901; Schnee, 1901; Phillips, 1923; Baker, 1951).

Numbers -- 1899 present (Reichenow, 1901).

Status -- Accidental.

Specimen Records -- None. The only other locality record for this species in the Marshall Islands is Kwajalein Atoll (Yocom, 1964).

9) Anas penelope European Widgeon

Habitat -- 26 October 1879 - caught by hand (Finsch, 1880a ; also Finsch, 1884; Wiglesworth, 1891; Kuroda in Momiyama, 1922; Phillips, 1923; Hand-list Japanese Birds, 1942; Baker, 1951).

Numbers -- 26 October 1879 - one present "... in full winter dress ... so exhausted ... merely a skeleton covered by feathers ..." (Finsch, 1880a, 1884).

Status -- Visitor.

Specimen Records -- Other - Finsch's specimen deposition not known. Baker (1951) questions this record. I do not agree with Baker. Although it is not clear in Finsch's 1880 papers as to the exact locality of this record in the Marshall Islands, Finsch (1884) lists Jaluit as the locality for a female specimen. No other record exists for this species in the Marshalls; however, it has been recorded in Western Micronesia (Baker, 1951); POBSP - none.

10) Anas acuta — Pintail

Habitat -- 1899 - present (Reichenow, 1901; Schnee, 1901; Phillips, 1923; Baker, 1951).

Numbers -- 1899 - present (Reichenow, 1901).

Status -- Common visitor.

Specimen Records -- None.

11) Aythya valisineria — Canvas back

Habitat -- 1899 present (Reichenow, 1901; Schnee, 1901; Baker, 1951); November 1964 - not present.

Numbers -- 1899 - present (Reichenow, 1901).

Status -- Uncommon visitor.

Specimen Records -- None. These sightings are the only records for this species from Micronesia.

12) Anatidae sp. — Duck species

Habitat -- 11 November 1964 - Elizabeth Island central lagoon (a small two-acre stagnant area next to a village).

Numbers -- 11 November 1964 -Elizabeth Island one unidentified duck seen, a native revealed that four unknown ducks had been shot on 10 November.

Status -- Accidental.

Specimen Records -- None.

13) Gallus gallus — Domestic Chicken

Habitat -- November 1964 - Jaluit Island present in and around the villages, Kabbenbock present and probably occurs on all inhabited islands in the atoll.

Numbers -- November 1964 - Jaluit and Kabbenbock no estimate made but probably many are raised to feed the population.

Status -- Resident breeder. November 1964 - breeds both within and outside the villages.

Specimen Records -- None. Although chickens were probably introduced to Jaluit Atoll very early, no mention of their occurrence is found in the literature.

14) Pluvialis dominica Golden Plover

Habitat -- August-September 1879, May 1880 (?) - present (Finsch, 1880b, 1884, and Baker, 1951); April-May 1958 - present on Imroj, Ribon, Jabor, and Pinlep (Gressitt in Blumenstock, 1961); November 1964 - observed on the beaches of Jaluit, Enybor, Kabbenbock, Elizabeth, and Lijeron.

Numbers -- November 1964 - Enybor Island 5-7, Kabbenbock 6-10, Jaluit and Elizabeth few, Lijeron 25.

Status -- Migrant.

Specimen Records -- Other - Gressitt (in Blumenstock, 1961) erroneously stated that this species had not been recorded at Jaluit Atoll prior to 1958; Finsch (1880b) observed and collected it in 1879, and 20 May 1880 (Finsch, 1884) collected a male beginning its summer plummage and beginning to molt, specimen deposition unknown; POBSP - two (Table 26).

15) Charadrius semipalmatus Semipalmated Plover

Habitat -- October 1879 - Finsch (1880c) reported "At the end of October ... I met ... with a bird which seems to be Charadrius hiaticula [synonym of C. semipalmatus], although I could not state this as certain."

Numbers -- October 1879 - one seen (Finsch, 1880c).

Status -- Uncommon migrant.

Specimen Records -- None. Wiglesworth (1891), Kuroda (in Momiyama, 1922), and Baker (1951), report this species from Jaluit Atoll on the basis of Finsch's (1880c) observation. The actual locality at which Finsch made his observation may not be Jaluit Atoll, since he states that during the latter part of September, October, and early November he was on a trip to the eastern chain of the Marshall Islands. Therefore, both the species identification and the locality is questioned. Baker (1951) states that "other than this observation, there is no history of the species in Micronesia." This statement is still valid.

16) <u>Charadrius</u> <u>mongolus</u> Mongolian Plover

Habitat -- 9 October 1931 - present on Jaluit Island (YIZM collection; Hand-list of Japanese Birds, 1932, 1942, 1958; Baker, 1951). Note: Baker erroneously listed Oustalet (1896) as a source for this record.

Numbers -- 9 October 1931 - two collected.

Status -- Vagrant.

Specimen Records -- Other - two (Table 27); POBSP - none.

17) Charadriinae sp. Plover species

Habitat -- 11 November 1964 - Jaluit Island on edge of an inland fresh-water pool.

Numbers -- 11 November 1964 - Jaluit Island one bird resembling a Golden Plover but larger and with a grayer head was observed in company of a Golden Plover by Clapp and Lehner.

Status -- Migrant.

Specimen Records -- None.

18) <u>Numenius</u> <u>phaeopus</u> Whimbrel

Habitat -- April-May 1958 - present on Jabor (Gressitt <u>in</u> Blumenstock, 1961); 10 November 1964 - observed on Kabbenbock beach.

Numbers -- April-May 1958 - present; 10 November 1964 - Kabbenbock one.

Status -- Migrant.

Specimen Records -- Other records - two (Table 27); POBSP - none. Note: Baker (1951) lists this species as being recorded on Jaluit Atoll, referring to Oustalet (1896) and Hand-list Japanese Birds (1932, 1942, and 1958). Oustalet (1896) does not list this species from Jaluit Atoll but refers to another kind of curlew, <u>N.</u> <u>tahitiensis</u>, taken by Finsch (1880a) at Jaluit Atoll.

19) <u>Numenius</u> <u>tahitiensis</u> Bristle-thighed Curlew

Habitat -- August-September 1879 and 13 April 1884 - present (Finsch, 1880a; also Kuroda <u>in</u> Momiyama, 1922; Bent, 1929; Hand-list Japanese Birds, 1932, 1942, 1958; and Baker, 1951); November 1964 - present on sandy and rocky beaches of Enybor, Jaluit, and Lijeron.

Numbers -- 5 September 1879 - a pair observed; 13 April 1880 - 1; November 1964 - present.

Status -- Migrant.

Specimen Records -- Other - Finsch (1884) reported a female from Jaluit collected on 21 October 1879 but present deposition unknown; POBSP - none.

20) Totanus melanoleucus Greater Yellowlegs

Habitat -- Not known.

Numbers -- One collected on 12 May 1932 on Jaluit Atoll (Kuroda, 1934; Hand-list Japanese Birds, 1942; Baker, 1951).

Status -- Accidental.

Specimen Records -- Other - one (Table 27); POBSP - none.

21) Heteroscelus incanum Wandering Tattler

Habitat -- August-September 1879, January and June 1880 - along the beaches (Finsch 1880b and 1884; Kuroda in Momiyama, 1922; Hand-list Japanese Birds, 1932, 1942, 1958; Baker, 1951); April-May 1958 - present on Kinajon, Jabor, Pinlep, and Majurirek (Elizabeth) (Gressitt in Blumenstock, 1961); November 1964 - present mainly on seaward beaches of Enybor, Kabbenbock, Jaluit, Elizabeth, and Lijeron.

Numbers -- August-September 1879 - in small numbers (Finsch, 1880b); 11 January and 13 June 1880 - one collected (Finsch, 1884); November 1964 - Enybor 7-8, Kabbenbock 16, Jaluit few, Elizabeth few, Lijeron 3.

Status -- Migrant.

Specimen Records -- Other - four (Table 27); Finsch (1884) reported taking from Jaluit a female in full winter plumage on 11 January 1880 and a male in full winter plumage (without a trace of molt) on 13 June 1880; however, the present specimen deposition is unknown; POBSP - none.

22) Arenaria interpres Ruddy Turnstone

Habitat -- August-September 1879 - present (Finsch 1880b; also Finsch, 1884; Kuroda in Momiyama, 1922; Hand-list Japanese Birds, 1932, 1942, 1958; and Baker, 1951); 10 January 1900 - present (Townsend and Wetmore, 1919); April-May 1958 - present on Jabor, Pinlep, and Lijeron (Gressitt in Blumenstock, 1961); November 1964 - on beaches of Enybor, Kabbenbock, Jaluit, Elizabeth, and Lijeron.

Numbers -- November 1964 - Enybor 10, Kabbenback 35-40, Jaluit few, Elizabeth few, Lijeron 30.

Status -- Migrant. Finsch (1880b) noted that all the turnstones were in their summer plumage.

Specimen Records -- Other - two (Table 27). Finsch (1884) reported two Ruddy Turnstones collected at Jaluit (a male in full summer plumage but in molt collected 12 September 1879, and a female in summer plumage collected 29 August 1879), specimen deposition unknown. POBSP - none.

23) Crocethia alba Sanderling

Habitat -- 25 October 1879 - present at Jaluit (Finsch, 1880b, 1884).

Numbers -- 25 October 1879 - one specimen received by Finsch (1880c, 1884). [Also listed by Wiglesworth (1891), Kuroda in Momiyama (1922), and Hand-list Japanese Birds (1932, 1942, 1958].

Status -- Migrant.

Specimen Records -- Other - present location unknown of male in full winter plumage, collected Jaluit Atoll, 25 October 1879 (Finsch, 1884); POBSP - none.

24) Erolia acuminata Sharp-tailed Sandpiper

Habitat -- 30 October 1931 - Jaluit Island (Yamashina collection).

Numbers - 30 October 1931 - present (Hand-list Japanese Birds, 1932, 1942, 1958; and Baker, 1951).

Status -- Migrant.

Specimen Records -- Other - two (Table 27); POBSP - none.

25) Sterna hirundo nigripennis Common Tern

Habitat -- 10 November 1964 - Enybor roosting on a sandbar in the lagoon in company with several S. sumatrana.

Numbers -- 10 November 1964 - Enybor one seen and collected.

Status -- Accidental.

Specimen Records -- Other - none; POBSP - one (Table 26). This is a new species and specimen record for the Marshall Islands.

26) <u>Sterna sumatrana</u> Black-naped Tern

Habitat -- August-October 1879 - present (Finsch 1880b, c; Wiglesworth, 1891; Kuroda <u>in</u> Momiyama, 1922; Hand-list Japanese Birds 1932, 1942, 1958; Baker, 1951); November 1964 - Enybor and Kabbenbock present on sandy beaches, sandbars, and surrounding lagoon areas, not seen on other islands.

Numbers -- August-October 1879 - present (Finsch 1880b, c); April-May 1958 - undoubtedly not present since Gressitt (<u>in</u> Blumenstock, 1961) did not list this species; November 1964 - Enybor 15, Kabbenbock approximately 5-7.

Status -- Resident breeder. Early October 1879, "... procured specimens ... in the first plumage ... not then able to fly ..." (Finsch, 1880d); November 1964 - no evidence of breeding, however, flying young were present.

Specimen Records -- Other - five (Table 27); POBSP - three (Table 26).

27) <u>Sterna fuscata</u> Sooty Tern

Habitat -- April 1958, "... a small uninhabited islet on the north-western reef of the atoll [possibly Lijeron], where the islanders gathered eggs and captured about 20 Sooty Terns to take home for eating" (Wiens, 1962); November 1964 - Lijeron a group emerged from the low underbrush (<u>Messerschmidia</u>) on the southwest corner of the island, circled the island; none returned to the ground.

Numbers -- April 1958 - present but population unknown (Wiens, 1962); November 1964 - Lijeron 25-30.

Status -- Resident breeder. April 1958 - eggs present (Wiens, 1962); November 1964 - Lijeron no eggs or chicks could be found, however, the three collected specimens had brood patches. The natives reported that a colony of a few hundred Sooty Terns nested on one of the other isolated islands during Christmastime 1963.

Specimen Records -- Other - none; POBSP - three (Table 26). These are new specimen records for Jaluit Atoll.

28) <u>Thalasseus bergii</u> Crested Tern

Habitat -- 1879-1880 - present (Finsch, 1884; Hand-list Japanese Birds, 1932, 1942, 1958; Baker, 1951); April-May 1958 - present on Lijeron (Gressitt <u>in</u> Blumenstock, 1961); November 1964 - present on sandy beaches, sandbars, beach rock outcrops, and surrounding lagoon areas of Enybor, Kabbenbock, Jaluit, and Lijeron (nesting on sandy peninsula).

Numbers -- November 1964 - Enybor 2, Kabbenbock 2-3, Jaluit 1, Lijeron 6.

Status -- Resident breeder. 1879-1880 - young female present (Finsch, 1884), "... beginning of January [1880] they were in full nuptial dress ... and at this time ... got fresh-laid eggs from this [Jaluit] lagoon, but was not able ... to find the breeding grounds ..." (Finsch, 1880c); November 1964 - Lijeron two chicks, about three-fourths grown, present on west sandbar.

Specimen Records -- Other - one (Table 27). Finsch (1884) reported two specimens from Jaluit, an old female in full plumage and a young female, however, it is not known where they are deposited; POBSP - three (Table 26).

29) Anous stolidus Brown Noddy

Habitat -- 1879-1880 - present on Jaluit (Finsch, 1884); Hand-list Japanese Birds, 1932, 1942, 1958; Baker, 1951); present on Majurirek, Ribon, Kinajon, Mejatto, Pinlep, and Lijeron (Gressitt in Blumenstock, 1961); November 1964 - present on Enybor, Kabbenbock, Jaluit, Majurirek (Elizabeth), and Lijeron (nesting on low-growing plants and very low limbs of Messerschmidia trees).

Numbers -- November 1964 - Enybor 20, Kabbenbock 8, Jaluit and Elizabeth a few, and Lijeron 25.

Status -- Resident breeder. 1879-1880 - nests at Jaluit (Finsch, 1884); November 1964 - Lijeron five nests, all with eggs, on fallen trees, in a low plant and on low limbs (large) of Messerschmidia trees.

Specimen Records -- Other - two (Table 27). Finsch (1884) reported an old male, a downy young, and three non-flying nestlings, but present deposition unknown; POBSP - five (Table 26).

30) Anous tenuirostris Black Noddy

Habitat -- August-September 1879 - present along the beaches (Finsch, 1880b and 1884; Oustalet, 1896; Kuroda in Momiyama, 1922; Hand-list Japanese Birds, 1932, 1942; Baker, 1951); Summer 1956 - "... white-capped grey noddy ... flew overhead." (Wiens, 1957); April-May 1958 - present on Mejatto, Ribon, Jabor, Kinaijon, Majurirek, and Lijeron in nests of Pisonia leaves on twigs (Gressitt in Blumenstock, 1961); November 1964 - present on Enybor, Kabbenbock, and Lijeron (nesting in Pisonia, Pemphis, and Messerschmidia).

Numbers -- August-September 1879 - observed in small numbers (Finsch, 1880b); April-May 1958 - large numbers on Lijeron (Gressitt in

Blumenstock, 1961); November 1964 - Enybor 1, Kabbenbock 2, Lijeron 1,000 estimated.

Status -- Resident breeder. April-May 1958 - abundant nests, eggs, and young birds on Lijeron (Gressitt _in_ Blumenstock); November 1964 - Lijeron approximately 400 nests with eggs and young, no nests seen on other islands visited.

Specimen Records -- Other - eight (Table 27). Finsch (1884) reported 5 specimens (4 male and 1 female) from Jaluit taken in 1879 or 1880, present disposition unknown; POBSP - five (Table 26).

31) _Gygis alba_ White Tern

Habitat -- August-September 1879 - along the beach (Finsch, 1880b; Hand-list Japanese Birds, 1932, 1942, 1958; Baker, 1951); Summer 1956 - flying overhead (Wiens, 1957); April-May 1958 - present on Mejatto, Ribon, Jabor, Majurirek, Pinlep, and Lijeron (Gressitt _in_ Blumenstock, 1961); November 1964 - present on Enybor, Kabbenbock, Jaluit, Elizabeth, and Lijeron (nesting on branches of _Messerschmidia_ and _Pisonia_).

Numbers -- August-September 1899 - a few examples present (Finsch, 1880b); November 1964 - Enybor 10, Kabbenbock 10, Jaluit and Elizabeth a few present, Lijeron 1,000 estimated.

Status -- Resident breeder. April-May 1958 - one egg seen (Gressitt _in_ Blumenstock, 1961); November 1964 - small number of eggs and young (all ages) were found.

Specimen Records -- Other - four (Table 27); POBSP - four (Table 26).

32) _Ducula oceanica_ Micronesian Pigeon

Habitat -- August-September 1879 - present (Finsch, 1880b, c, and 1884; Kuroda _in_ Momiyama, 1922; Takatsukasa and Yamashina, 1932; Hand-list Japanese Birds, 1932, 1942; Peters, 1937; Amadon, 1943; Mayr, 1945; Baker, 1951); April-May 1958 - present on Kinajon (Gressitt _in_ Blumenstock, 1961).

Numbers -- August-September 1879 - one seen and collected (Finsch, 1880b, c, and 1884); April-May 1958 - no estimate given (Gressitt _in_ Blumenstock, 1961).

Status -- Resident breeder. August-September 1879 - "... got ... a young _carpophaga_ which had just left the nest, apparently _D. oceanica_" (Finsch, 1880b).

Specimen Records -- Other - six (Table 27); Finsch (1884) reported a young female, in first plumage from Jaluit but its present deposition is unknown; POBSP - none.

33) Urodynamis taitensis New Zealand Cuckoo

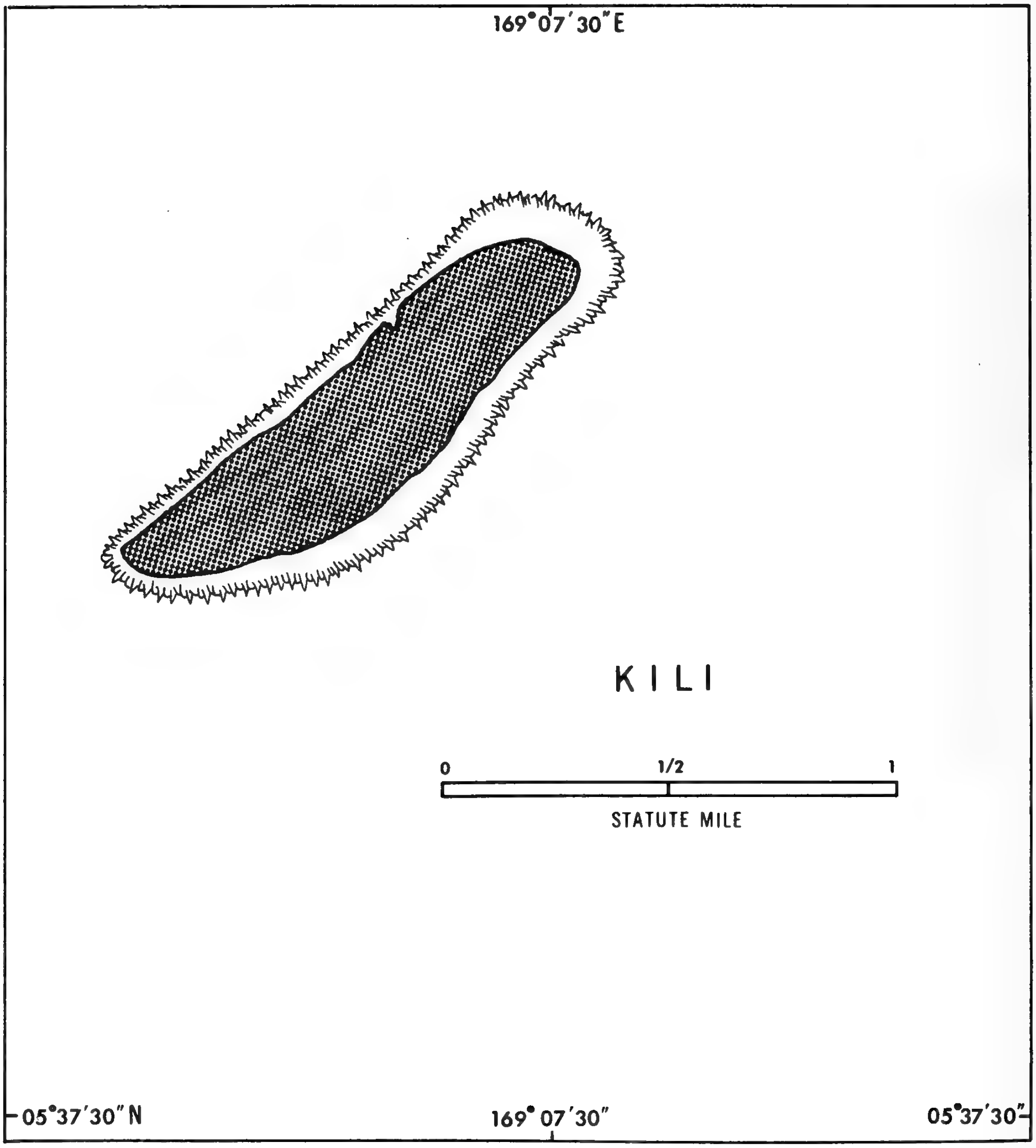
Habitat -- 21 October, 5 September 1879 and 13 April 1880 - present "... stomach contained wing-coverts of beetles, remains of caterpillars, and a few seeds" (Finsch, 1880b; Finsch, 1884, 1900; Wiglesworth, 1891; Kuroda in Momiyama, 1922; Hand-list Japanese Birds, 1932, 1942; Bogert, 1937; Baker, 1951); April-May 1958 - present on Jabor and Lijeron (Gressitt in Blumenstock, 1961); November 1964 - observed in vegetation near inland pond on Elizabeth.

Numbers -- 21 October 1879 - one collected, no others seen, one pair observed on 5 September 1879, and one individual seen on 13 April 1880 (Finsch 1880b, c, and 1884); April-May 1958 - no population estimate given (Gressitt in Blumenstock, 1961); November 1964 - one observed on Elizabeth, probably very few on the atoll.

Status -- Migrant. Finsch (1884) noted that a female he collected at Jaluit had a brood patch similar to one reported by Buller in New Zealand. He and Wiglesworth (1893) suggested that this species possibly bred in the Marshall Islands.

Specimen Records -- Other - one (Table 27). Finsch (1880b and 1884) reported a female collected at Jaluit on 21 October 1879 but the present disposition of this specimen is unknown; POBSP - none.

348-415 O-69—14


169°07'30"E
KILI
0
1/2
1
STATUTE MILE
05°37'30"N
169° 07'30"
05°37'30"

KILI ISLAND

Location: 05°39' N x 169°04' E.

Shape and Size: Oval-shaped; Tip to tip (northeast-southwest) - 1 mile; Widest point (southeast-northwest) - 0.33 mile; No lagoon but a brackish pond and a freshwater swamp are present; Total dry land area - 0.36 square mile; Number of islands - 1; Height ? feet (Fosberg, 1956).

Soil: Beach - mostly high boulders and rocky, except for sandy area in southwest and northern sectors.

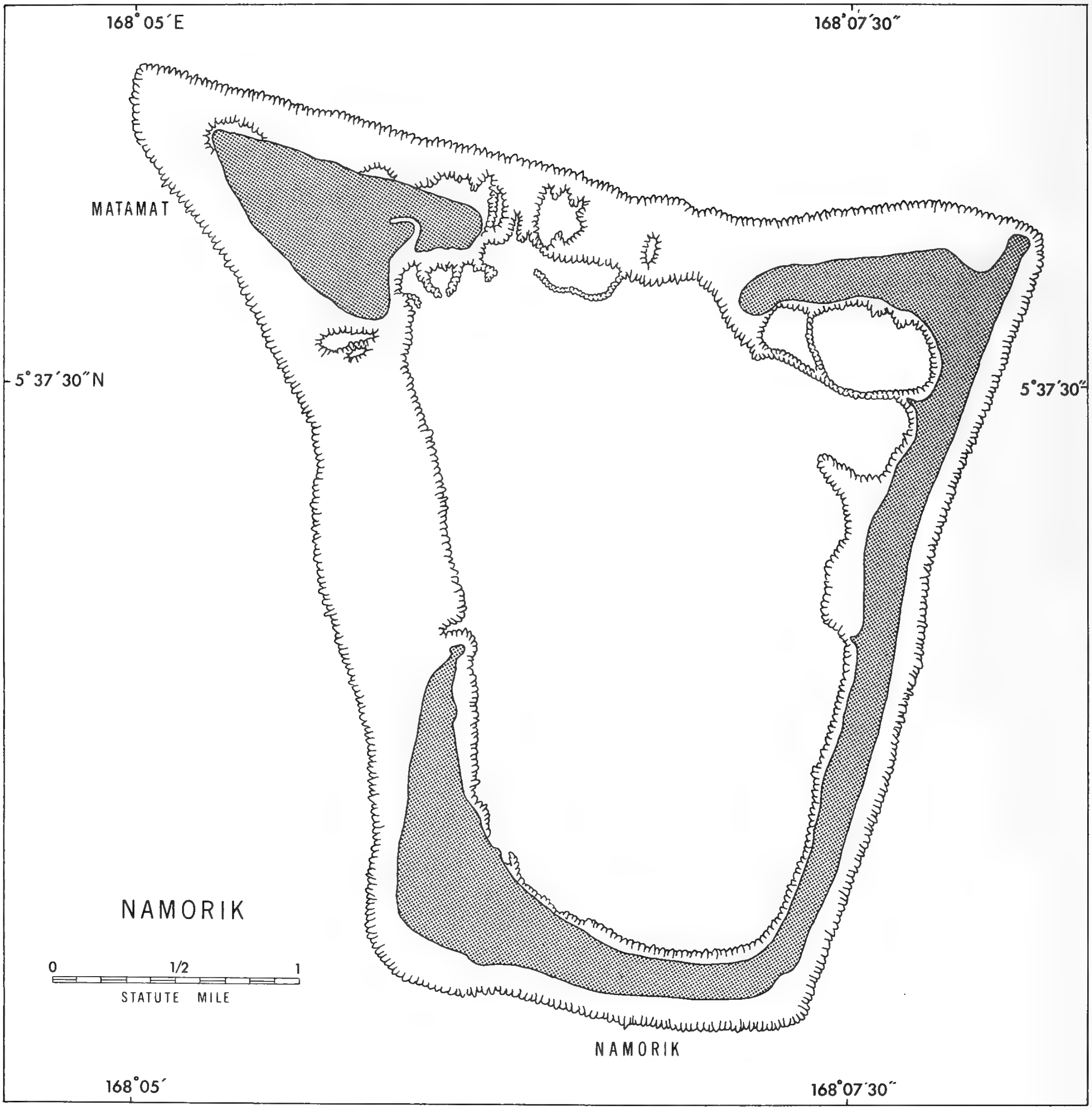
Vegetation: Eleven known species; high vegetation, numerous *Cocos*, *Pandanus*, and *Artocarpus* (Wiens, 1957).

Climate: Very wet, about 120-160 inches rainfall yearly; Mean air temperature-82° F.; Wind - prevailing from north, east, and southeast (Fosberg, 1956).

Human Population: Past - uninhabited; in 1948 settled by 184 relocated Bikini inhabitants. Present - inhabited, 287 in 1964 (U.S. Dept. of State, 1965).

Scientific Visits: W. H, Hatheway - September 1952; Pacific Science Board (H. J. Wiens) - summer 1956.

Avifauna: No bird records exist for Kili Island.


168° 05′ E
168° 07′ 30″
MATAMAT
5° 37′ 30″ N
5° 37′ 30″
NAMORIK
0
1/2
1
STATUTE MILE
NAMORIK
168° 05′
168° 07′ 30″

NAMORIK ATOLL

Location: 05°36' N x 168°07' E.

Shape and Size: Irregular rectangle-shaped; Tip to tip (north to south) - 3.75 miles; Width (east-west) - widest 3.50 miles; Total lagoon area - 3.25 square miles. Total dry land area - 1.07 square miles; Number of islands - 2; Height - 10 feet (Fosberg, 1956).

Soil: No available data.

Vegetation: Five known species; both islands wooded.

Climate: Very wet, about 120-160 inches of rainfall yearly; Mean air temperature - 82° F.; Winds - prevailing from north, east, and southeast (Fosberg, 1956; U.S. Navy, 1964).

Human Population: Past - inhabited, 300 in 1800's (Findlay, 1886); 461 in 1948 (Freeman, 1951); Present - inhabited, 534 in 1964 (U. S. Dept. of State, 1965).

Scientific Visits: None.

Avifauna: Three bird species are known from Namorik Atoll. Two of these species are seabirds, and the other is a domestic fowl. All three species are potential breeders, but none have, so far, been recorded as breeding.

The three species are included in the following checklist. This list was compiled from source material, which included: (1) Baker, 1951; (2) Hand-list of Japanese Birds, (a) 1932, (b) 1942; (3) Yale Cross-Cultural Survey, 1932; and (4) YIZM collection. These sources are referred to in the checklist by corresponding numbers and letters.

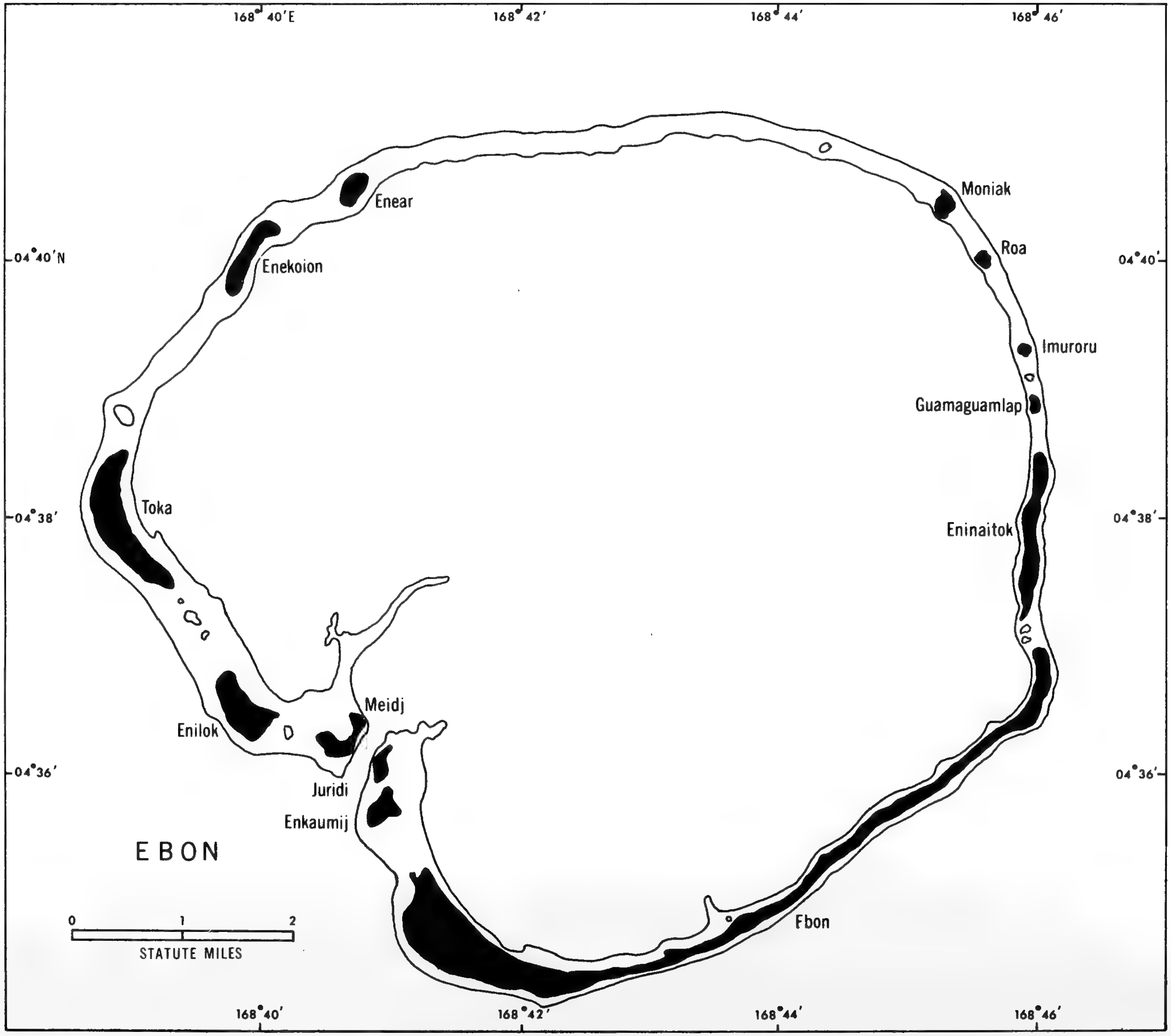
Namorik Atoll Avifauna Checklist

Species	Status	Source
1) *Phaethon lepturus*	Resident breeder ?	1, 2b
2) *Gallus gallus*	Introduced breeder ?	3
3) *Anous tenuirostris*	Resident breeder ?	1, 2a, 4

Bird specimens from Namorik Atoll include only one specimen, which is located in the Yamashina collection in Tokyo, Japan.

Table 28. Bird specimens collected from Namorik Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anous tenuirostris	YIZM	-	-	Namorik I	10-17-31	Skin	H. Orii



168° 40′E
168° 42′
168° 44′
168° 46′
04° 40′N
04° 38′
04° 36′
04° 40′
04° 38′
04° 36′
Enear
Moniak
Enekoion
Roa
Imuroru
Guamaguamlap
Toka
Eninaitok
Meidj
Enilok
Juridi
Enkaumij
EBON
0
1
2
STATUTE MILES
Fbon
168° 40′
168° 42′
168° 44′
168° 46′

EBON ATOLL

Location: 04°38' N x 168°43' E.

Shape and Size: Irregular oval-shaped; Diameter - (north-south) 8 miles, (east-west) 7 miles; Total lagoon area - 40.09 square miles; Total dry land area-2.22 square miles;Number of islands-22;Height-3 feet (Fosberg,1956).

Soil: Beach (ocean side of Ebon Island) - firm sand to gravelly sand; Beach (lagoon side of Ebon Island) - generally rocky to gravelly, with extensive rock flats exposed at low tide; Interior - sandy to black humus (Wiens, 1957). Presence of about 50 to 100 thousand tons of phosphatic rock (Hatheway, 1957).

Vegetation: Twenty known species; main island one of richest in Marshall Islands, jungle-like dense central area, many Cocos (Wiens, 1957).

Climate: Very wet, about 120-160 inches of rainfall yearly; Mean air temperature - 82° F.; Wind - prevailing from north, east and southeast (Fosberg, 1956, U. S. Navy, 1964).

Human Population: Past - inhabited, 1,200 in 1800's (Findlay, 1886), 747 in 1948 (Freeman, 1951);Present - inhabited, 953 in 1963 (U.S. Dept. of State, 1965).

Scientific Visits: W. H. Hatheway - September 1952; Pacific Science Board (H. J. Wiens) - summer 1956.

Avifauna: Three bird species are known from Ebon Atoll. These include a seabird species, a domestic fowl, and a dove, the latter possibly extinct. No birds are known to breed on the atoll; however, 2 species are potential breeders.

A checklist, including status and source, of the bird species from Ebon Atoll follows. The source material for the list includes: (1) Baker, 1951; (2) Hand-list of Japanese Birds, (a) 1932, (b) 1942, (c) 1958; (3) Yale Cross-cultural Survey, 1932; (4) Hager, 1886; (5) Peters and Griscom, 1928; (6) Peters, 1937; (7) Ripley and Birckhead, 1942; and (8) YIZM collection. These sources are referred to in the checklist by corresponding numbers and letters.

Ebon Atoll Avifauna Checklist

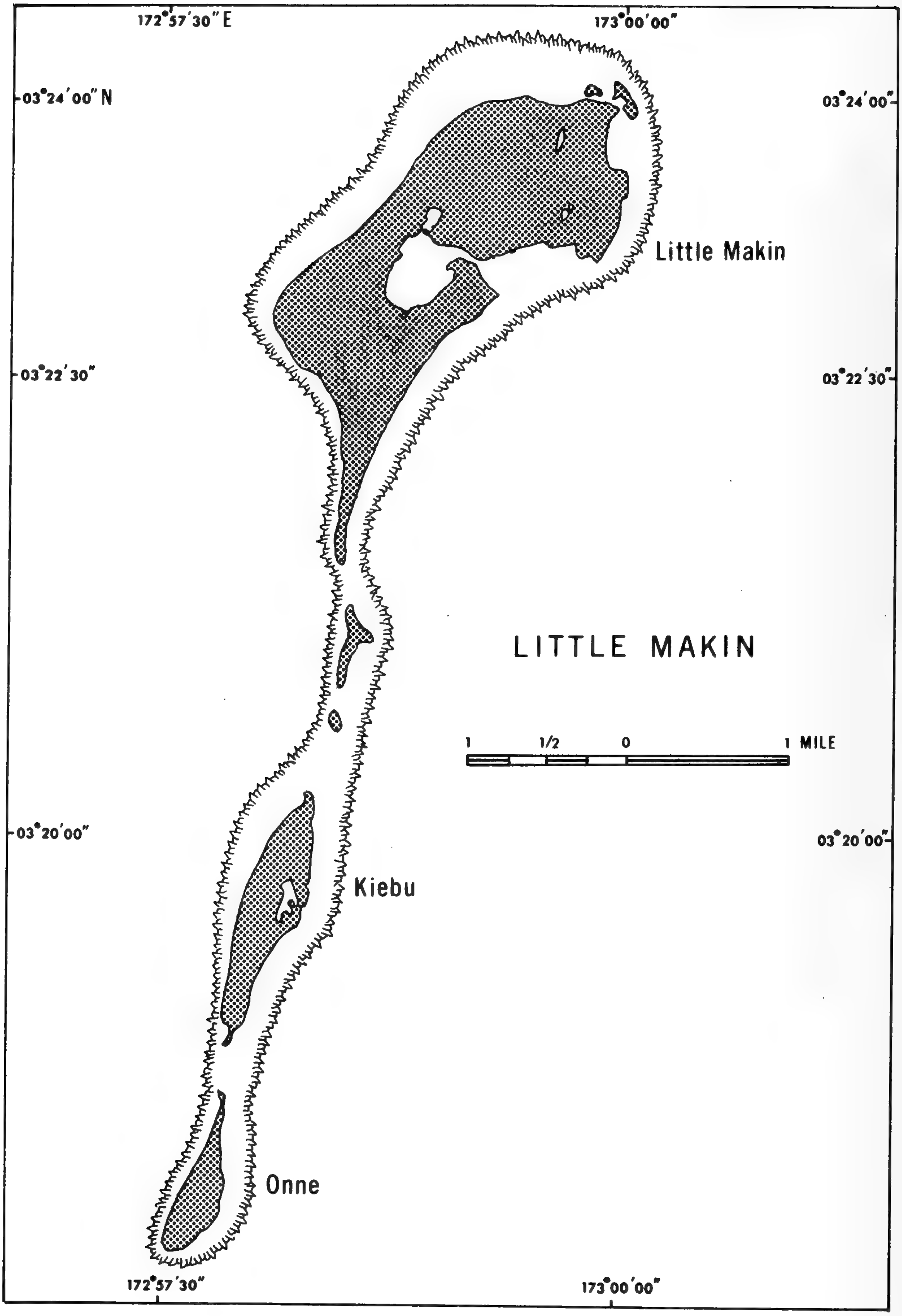
Species	Status	Source
1) *Gallus gallus*	Introduced breeder ?	3, 4
2) *Anous tenuirostris*	Resident breeder ?	1, 2ab
3) *Ptilinopus porphyraceus hernsheimi*	Extinct ?	1, 2ab, 5, 6, 7

Bird specimens collected from Ebon Atoll includes 3 specimens of 2 species.

Table 29. Bird specimens collected from Ebon Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anous tenuirostris	YIZM	♂	A	Ebon I	10-16-31	Skin	H. Orii
" "	"	♂	A	"	"	"	"
Ptilinopus porphyraceus	MCZ	?	A	"	late 1859	"	B. G. Snow

G I L B E R T   I S L A N D S



172°57'30" E
173°00'00"
03°24'00" N
03°24'00"
Little Makin
03°22'30"
03°22'30"
LITTLE MAKIN
1 1/2 0 1 MILE
03°20'00"
03°20'00"
Kiebu
Onne
172°57'30"
173°00'00"

LITTLE MAKIN ATOLL

Location: 03°17' N x 172°58' E.

Shape and Size: String of four islands situated north-south about seven miles long; Total land area - 2.80 square miles; No lagoon (Agassiz, 1903; Mason *in* Freeman, 1951).

Soil: Mainly coral and organic matter (see Catala, 1957 for detailed analysis).

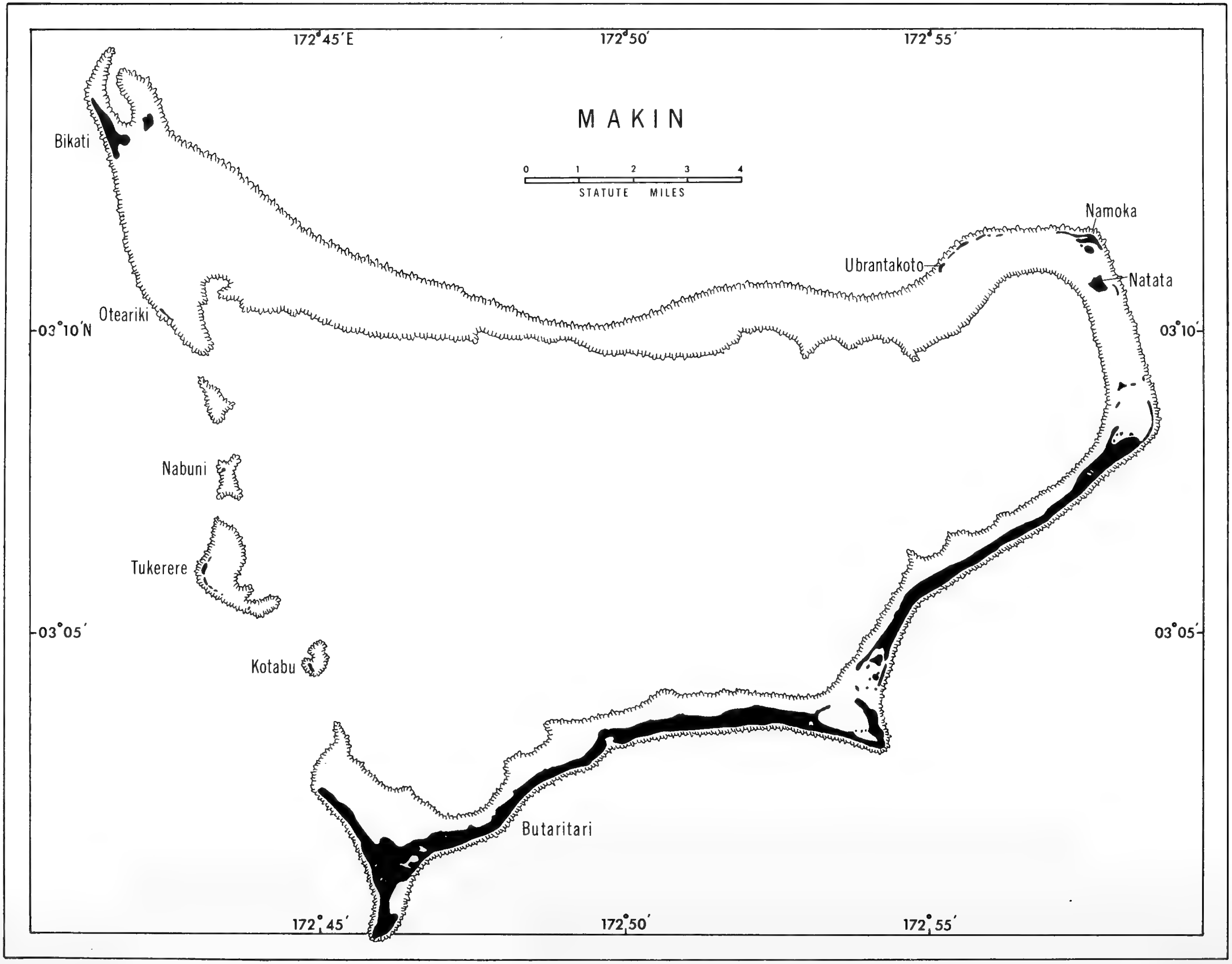
Vegetation: Mainly *Cocos*, four other plant species listed (Catala, 1957).

Climate: Wet, rainfall averages 100.23 inches yearly; Air temperature averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 908 (Catala, 1957).

Scientific Visits: O. Finsch (1880d) - November-December 1879; "Albatross" Tropical Pacific Expedition - 1900 (Agassiz, 1903); L. A. Catala (Catala, 1957) - 6 March to 30 August 1951. [Note: Child (1960) did not visit little Makin (Child, personal communication, August 1965)].

Avifauna: No birds have been recorded from Little Makin Atoll. Due to the closeness (2 miles) of Little Makin to Makin Atoll, most of the bird species found on the latter possibly occur on the former.



MAKIN
0 1 2 3 4
STATUTE MILES
172°45′E
172°50′
172°55′
03°10′N
03°05′
03°10′
03°05′
172°45′
172°50′
172°55′
Bikati
Oteariki
Nabuni
Tukerere
Kotabu
Butaritari
Ubrantakoto
Namoka
Natata

MAKIN ATOLL

Location: 03°07' N x 172°48' E.

Shape and Size: An irregular-shaped triangle; north side - 21 miles; west side - 18 miles; Total lagoon area - 74 square miles; Total dry land area - 4.5 square miles; Number of islands - 11+ (Mason in Freeman, 1951).

Soil: Outer beach - mostly rocky but some sandy area; Inner beach - mostly sandy but some rocky area, large salt-flat area on Butaritari Island; Inland soil - shallow layer of peat over sandy coral fragment material (Catala, 1957).

Vegetation: Most islands planted in *Cocos*, some *Pisonia*.

Climate: Very wet, average rainfall 121.50 inches yearly; Air temperature averages 83-84° F., Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 2,510 (Catala, 1957).

Scientific Visits: O. Finsch (1880d, 1884) - 6 December 1879; J. G. Bremer (North, 1894, 1896) - 22-23 June 1894; U.S. Fish Commission Expedition (Townsend and Wetmore, 1919) - 6 January 1900; South Pacific Commission Scientific Expedition (Catala, 1957) - 6 March-30 August 1951; R. O. Morris - 26 November-11 December 1962, 11 July-20 August 1963 (visitation date to Makin unknown); POBSP - 13-15 November 1964. [Note: Child (personal communication, August 1965) did not visit Makin while Education Officer at Tarawa between February 1953 and February 1956 (Child, 1960).]

Avifauna: Twenty-four bird species are known from Makin Atoll. These include 11 seabirds, 8 shorebirds, 2 ducks, 1 heron, 1 landbird, and 1 domestic fowl. Four of these species are known breeders, 8 others are possible breeders, 10 are migrants, and 2 are vagrants.

Makin Atoll is the only locality in the Marshall and Gilbert Islands from which a *Himantopus* species is known.

Twenty-four species are listed in the following checklist, which was derived from various sources: (1) POBSP, (a) 1964, (b) band return; (2) Morris, 1963; (3) Finsch, (a) 1880d, (b) 1884; (4) North, (a) 1894, (b) 1896; (5) AOU Checklist, 1957; (6) Catala, 1957; and (7) Townsend and Wetmore, 1919. These sources are referred to in the checklist by their corresponding numbers and letters. The 11 species marked by a single asterisk are new species records for Makin Atoll; the four species marked by double asterisks are new atoll breeding records.

Makin Atoll Avifauna Checklist

	Species	Status	Source
1)	Sula dactylatra	Visitor	1b
2)	Sula sula*	Resident breeder ?	1a
3)	Sula leucogaster	Resident breeder ?	1a, 2
4)	Fregata minor*	Resident breeder ?	1a
5)	Fregata ariel*	Resident breeder ?	1a
6)	Egretta sacra	Resident breeder ?	1a, 2, 3a
7)	Anas clypeata	Migrant	4a, 5
8)	Anatidae sp.	Migrant	1a
9)	Gallus gallus	Introduced breeder ?	1a, 6
10)	Pluvialis dominica	Migrant	1a, 7
11)	Numenius phaeopus*	Migrant	1a
12)	Numenius tahitiensis	Migrant	1a, 7
13)	Limosa lapponica*	Migrant	1a
14)	Heteroscelus incanum	Migrant	1a, 3b, 7
15)	Arenaria interpres	Migrant	1a, 7
16)	Erolia accuminata	Migrant	1a, 7
17)	Himantopus sp.*	Accidental	1a
18)	Sterna sumatrana*	Resident breeder**	1a
19)	Sterna fuscata*	Resident breeder ?	1a
20)	Thalasseus bergii*	Resident breeder ?	1a
21)	Anous stolidus	Resident breeder**	1a, 3b
22)	Anous tenuirostris*	Resident breeder**	1a
23)	Gygis alba*	Resident breeder**	1a
24)	Urodynamis taitensis	Migrant	1a, 3, 4ab

POBSP personnel have collected 70 specimens of 15 species (Table 30). Of these 15 species, 7 are specimen records of species not previously known from Makin Atoll; 2 represent the first specimen confirmation of species previously known only from sight records; the other 6 are specimens of species from the atoll already represented in museum collections. Seventeen other specimens of 7 species are known from Makin; these are located in two museums (Table 31). In all, 87 specimens of 17 species are known from Makin Atoll.

Table 30. Bird specimens collected by POBSP from Makin Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Sula leucogaster	USNM 494887	♀	Imm	Kotabu	11-13-64	Skin	Amerson
" "	" 494888	?	A	Lagoon 3 mi. N. Butaritari	11-14-64	"	"
Fregata minor	" 494877	♀	Imm	Kotabu	11-13-64	"	"
Fregata ariel	" 494874	♂	A	"	"	"	"
" "	" 494875	♂	A	"	"	"	"
Egretta sacra	" 494860	♂?		"	"	"	Clapp
" "	" 494861	♂		"	"	"	Lehner
" "	" 494862	♂		"	"	"	"
Pluvialis dominica	" 494720	♂		Butaritari	11-14-64	"	Huber
" "	" 494721	♂		"	"	"	"
" "	" 494754	♂		Kotabu	11-13-64	"	Clapp
" "	" 494755	♀		Butaritari	"	"	Huber
" "	" 494756	♂		"	"	"	"
Numenius tahitiensis	" 494825	♂		"	11-14-64	"	"
" "	" 494826	♀		"	11-15-64	"	Amerson
" "	" 494827	♀		"	"	"	Huber
Limosa lapponica	" 494831	♂		"	11-13-64	"	"
" "	" 494832	♂		"	11-15-64	"	Clapp
" "	" 494833	♂		"	"	"	Huber
" "	" 494834	♀		"	"	"	Clapp
" "	" 494835	♀		"	"	"	"
Heteroscelus incanum	" 494900	♀		Kotabu	11-14-64	"	Lehner
" "	" 494901	♂		Butaritari	"	"	Huber
" "	" 494902	♂		"	"	"	"
" "	" 494903	♀		"	"	"	Wislocki
" "	" 494904	♂		"	"	"	"
" "	" 494905	♀		"	"	"	Huber
" "	" 494906	♂		"	"	"	"
Arenaria interpres	" 494755	♀	Imm	Tukerere	"	"	Amerson
" "	" 494766	♀		Butaritari	"	"	Huber
" "	" 494777	♀		"	"	"	"
Erolia acuminata	" 494806	♂		"	11-13-64	"	"
" "	" 494807	♂		"	11-14-64	"	"
" "	" 494808	♂		"	"	"	Wislocki
" "	" 494809	♀		"	"	"	Huber
Sterna sumatrana	" 494601	?		Lagoon 1 mi. E.of Tukerere	"	"	Amerson
" "	" 494602	♂		"	"	"	"
" "	" 494603	♀		Sandbar 1/2 mi. SE Tukerere	"	"	Lehner
" "	" 494604	♀		"	"	"	Amerson
" "	" 495883	♂		"	"	"	"
" "	" 495884	♂		"	"	"	"
" "	" 495885	♂		"	"	"	"

Table 30 (cont.). Bird specimens collected by POBSP from Makin Atoll.

Species	Museum		Sex	Age	Location	Date	Status	Collector
Thalasseus bergii	USNM	494734	?		Kotabu	11-13-64	Skin	Amerson
" "	"	494735	♀		"	"	"	"
" "	"	494736	?	Imm	"	"	"	"
" "	"	494737	♂		"	"	"	"
Anous stolidus	"	494671	♂?	Nest.	"	11-14-64	"	"
" "	"	494672	♀		"	"	"	"
" "	"	494673	♀		"	"	"	"
" "	"	494674	♂		"	"	"	"
Anous tenuirostris	"	494556	♂		"	11-13-64	"	"
" "	"	494557	♂		"	"	"	"
" "	"	494558	♀		"	"	"	"
" "	"	494559	♀		"	"	"	Lehner
" "	"	494560	♀		"	"	"	"
" "	"	494561	♂		"	"	"	"
" "	"	494562	♂		"	"	"	"
" "	"	494563	♀		"	"	"	"
" "	"	494564	♂		"	"	"	"
" "	"	494565	♂		"	"	"	"
" "	"	494566	♀		"	"	"	"
" "	"	494567	♀		"	11-14-64	"	Amerson
Gygis alba	"	494637	♀		"	11-13-64	"	Lehner
" "	"	494638	♂		"	"	"	"
" "	"	494639	♀		"	"	"	"
" "	"	494640	♂		"	11-14-64	"	"
" "	"	494641	♀		"	"	"	"
" "	"	494642	--		"	"	"	"
" "	"	494643	♂		"	"	"	"
" "	"	494644	♂		"	"	"	"

Table 31. Bird specimens collected by other expeditions from Makin Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Anas clypeata	Aus.M. 07956	♀		Big Makin*	06-22-94	-	Bremer
" "	" 07957	♂		"	06-23-94	-	"
Pluvialis dominica	MCZ 81925	♀		Taritari *	01-06-00	Skin	Townsend
" "	USNM 212226	♀		"	"	"	"
" "	" 212227	♀		"	"	"	"
Numenius tahitiensis	" 212197	♂		"	"	"	"
" "	" 212198	♀		"	"	"	"
" "	" 212199	♂		"	"	"	"
" "	" 212200	♀		"	"	"	"
Heteroscelus incanum	" 212185	♀		"	"	"	"
Arenaria interpres	" 212209	♀		"	"	"	"
" "	" 212210	♂		"	"	"	"
Erolia accuminata	" 212182	♀		"	"	"	"
" "	" 212183	♂		"	"	"	"
" "	" 212184	♂		"	"	"	"
Urodynamis taitensis	Aus.M. 07958	♀		Butaritari	06-01-94	"	Swayne
" "	" 07959	♂		"	"	"	"

*Probably Butaritari Island

348-415 O-69—15

Species Accounts

1) Sula dactylatra Blue-faced Booby

See Banded Bird Recaptures, Appendix A.

2) Sula sula Red-footed Booby

Habitat -- 13 November 1964 - Kotabu - one light-phase adult approached the island at dusk apparently to roost.

Numbers -- 13 November 1964 - Kotabu - 1.

Status -- Resident breeder? No evidence of breeding on islands visited; however, this species may possibly breed on the atoll.

Specimen Records -- None. This is a new species sight record for Makin Atoll.

3) Sula leucogaster Brown Booby

Habitat -- November-December 1962 and July-August 1963 - perched on beacons and poles in the lagoon (Morris, 1963); November 1964 - perched on poles in the lagoon and observed returning to Kotabu Island at dusk to roost.

Numbers -- November-December 1962 and July-August 1963 - "... never seen in any number ..." (Morris, 1963); November 1964 - Kotabu 2, lagoon 1.

Status -- Resident breeder? No breeding observed. It is possible, however, that this species breeds on some of the isolated islands in Makin Atoll.

Specimen Records -- Other - none; POBSP - two (Table 30). These represent new specimen records for Makin Atoll.

4) Fregata minor Great Frigatebird

Habitat -- 13 November 1964 - Kotabu - over island during daytime and roosting there at night; not seen on or over other islands in the atoll.

Numbers -- 13 November 1964 - Kotabu 60 estimated.

Status -- Resident breeder? No evidence of breeding on islands visited; however, this species possibly nests on the atoll if conditions are favorable.

Specimen Records -- Other - none; POBSP - one (Table 30). This collection represents a new species and specimen record for Makin Atoll.

5) *Fregata ariel* Lesser Frigatebird

Habitat -- 13 November 1964 - arrived on Kotabu to roost at dusk with *Fregata minor*.

Numbers -- 13 November 1964 - Kotabu 5-10 estimated; none seen on the other islands visited.

Status -- Resident breeder? Breeding not observed; however, breeding may occur.

Specimen Records -- Other - none; POBSP - two (Table 30). These represent a new species and specimen record for Makin Atoll.

6) *Egretta sacra* Reef Heron

Habitat -- December 1879 - along the shores (Finsch, 1880d); November-December 1962, July-August 1963-present (Morris, 1963); November 1964 - common, shores of Butaritari, Kotabu, and Nabuni, and on a sandbar between Kotabu and Tukerere.

Numbers -- December 1879 - "... saw uniformly white birds going always in pairs ... also ... pairs, undoubtedly male and female, of which one was white the other slate-coloured, or both of the latter colour or mixed with white." (Finsch, 1880d); November 1964 - Butaritari 50± (about 50-50 ratio between white- and dark-phase individuals), Kotabu 6, Nabuni Island 1, sandbar between Kotatu and Tukerere 1.

Status -- Resident breeder? Breeding not observed; however, this species probably breeds on Makin Atoll.

Specimen Records -- Other - none; POBSP - three (Table 30). Although this species has been observed at Makin Atoll previously, these are the first specimens to be collected from the atoll.

7) *Anas clypeata* Shoveler

Habitat -- June 1884 - present (North, 1894); also A.O.U. Checklist (1957).

Numbers -- June 1884 - 2 seen and collected (North, 1894).

Status -- Migrant; North (1894) notes that "previously this species had never been seen on the island, and the natives expressed an opinion that they had been probably blown there by one of the western gales ..."

Specimen Records -- Other - two (Table 31); POBSP - none.

8) Anatidae sp. Duck species

Habitat -- November 1964 - Butaritari mud flats.

Numbers -- November 1964- Butaritari 4.

Status -- Migrant.

Specimen Records -- None.

9) Gallus gallus Domestic Chicken

Habitat -- 1951 - present throughout the Gilbert Islands (Catala, 1957); November 1964 - present in and around the main village on Butaritari.

Numbers -- November 1964 - population not known; however, there must be a large number to keep the natives supplied with food.

Status -- Introduced breeder? Probably breeds in and around village.

Specimen Records -- None.

10) Pluvialis dominica Golden Plover

Habitat -- January 1900- present (Townsend and Wetmore, 1919); November 1964- present on the sandy and rocky beaches of Butaritari (mainly on the mud-flats), Kotabu, Tukerere, and Nabuni.

Numbers -- January 1900 - three specimens collected November 1964 - Butaritari 200-300, Kotabu 6-8, Tukerere 5, Nabuni 4.

Status -- Migrant.

Specimen Records -- Other - three (Table 31); POBSP - five (Table 30).

11) Numenius phaeopus Whimbrel

Habitat -- November 1964- present on the mud flats of Butaritari, not seen on the other islands visited.

Numbers -- November 1964 - Butaritari 30 estimated.

Status -- Migrant.

Specimen Records -- None. This observation is a new species sight record for Makin Atoll.

12) Numenius tahitiensis Bristle-thighed Curlew

Habitat -- January 1900 -present (Townsend and Wetmore, 1919); November 1964- present on sandy and rocky beaches of Butaritari (mainly on the mud-flats) Kotabu, and Tukerere.

Numbers -- January 1900 -four collected; November 1964 - Butaritari 25, Kotabu 1, Tukerere 1.

Status -- Migrant.

Specimen Records -- Other - four (Table 31); POBSP - three (Table 30).

13) Limosa lapponica Bar-tailed Godwit

Habitat -- November 1964- present only on the mud-flats of Butaritari, not observed on the other islands visited.

Numbers -- November 1964 -Butaritari 120 estimated.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - five (Table 30). This collection represents a new species and specimen record for Makin Atoll.

14) Heteroscelus incanum Wandering Tattler

Habitat -- December 1879- present on Butaritari (Finsch, 1884); January 1900- present (Townsend and Wetmore, 1919); November 1964- present on sandy and rocky beaches of Butaritari (mainly on the mud-flats), Kotabu, and Nabuni.

Numbers -- December 1879- 1 collected (Finsch, 1884); 6 January 1900- 1 collected; November 1964- Butaritari 300, Kotabu 6, Nabuni 2.

Status -- Migrant.

Specimen Records -- Other - two: one present location unknown, ♂ in winter plumage, Butaritari 6 December 1879, collector Finsch (Finsch, 1884); second (Table 31); POBSP - seven (Table 30).

15) Arenaria interpres Ruddy Turnstone

Habitat -- January 1900 -present (Townsend and Wetmore, 1919); November 1964 -present on sandy and rocky beaches of Butaritari (mainly on the mud flats), Kotabu, and Tukerere.

Numbers -- January 1900 - 2 collected; November 1964 - Butaritari 500-600, Kotabu 10, Tukerere 25.

Status -- Migrant.

Specimen Records -- Other - two (Table 31); POBSP - three (Table 30). USNM #494775 had USFW Band #652-49186 and was banded by POBSP at East Killing Ground, St. George, Pribilof Islands, Alaska, 31 August 1964. Another specimen, field #30302, 96 grans, Butaritari Island, 14 November 1964, collector Huber, was lost in transit.

16) Erolia acuminata Sharp-tailed Sandpiper

Habitat -- January 1900- present (Townsend and Wetmore, 1919); November 1964- present only on the mud-flats of Butaritari, not present on other islands visited.

Numbers -- January 1900- 3 collected; November 1964- Butaritari 25.

Status -- Migrant.

Specimen Records -- Other - three (Table 31); POBSP - four (Table 30). Another specimen probably this species, field #30307, 64 grams, Butaritari Island, 14 November 1964, collector Wislocki, was lost in transit.

17) Himantopus sp. Stilt species

Habitat -- November 1964 - Butaritari mud-flats.

Numbers -- November 1964- Butaritari 1.

Status -- Accidental.

Specimen Records -- None. This observation represents a new species sight record for the Marshall and Gilbert Islands.

18) Sterna sumatrana Black-naped Tern

Habitat -- November 1964- observed flying over and feeding in the lagoon, nests on ground (no nest material used) on sandbar between Kotabu and Tukerere Islands.

Numbers -- November 1964 - in lagoon, on sandbar between Kotabu and Tukerere Island, 60 estimated.

Status -- Resident breeder. November 1964 - nesting on sandbar. This is a new breeding record for Makin Atoll.

Specimen Records -- Other - none; POBSP - seven (Table 30). This collection represents a new species and specimen record for Makin Atoll.

19) Sterna fuscata Sooty Tern

Habitat -- November 1964 - heard flying over lagoon at night.

Numbers -- November 1964 - 1 heard.

Status -- Resident breeder? November 1964 - not breeding. This species may possibly breed at Makin Atoll.

Specimen Records -- None. This is a new record for Makin Atoll.

20) Thalasseus bergii Crested Tern

Habitat -- November 1964 - flying over adjacent lagoon areas and nesting on rocks and poles at Butaritari (also over mud-flats), Kotabu, and Nabuni, and the sandbar between Kotabu and Tukerere.

Numbers -- November 1964 - Butaritari few present, Kotabu 10, Nabuni 2, sandbar 12.

Status -- Resident breeder? November 1964 - no breeding observed; however, this species may breed on some of the isolated islands and sandbars not visited.

Specimen Records -- Other - none; POBSP - four (Table 30). This collection represents a new species and specimen record for Makin Atoll.

21) Anous stolidus Brown Noddy

Habitat -- December 1879 - present (Finsch, 1884); November 1964- Butaritari present in the vegetated areas (mainly in Cocos), Kotabu flying over the island and nesting on rocks and low vegetation.

Numbers -- December 1879 - 1 collected; November 1964 - Butaritari few present, Kotabu 25.

Status -- Resident breeder. November 1964 - Kotabu several nests with eggs and chicks present; the three adults collected had bare brood patches. This species probably breeds on the other islands in the atoll as well. This is a new breeding record for the atoll.

Specimen Records -- Other - one: whereabouts unknown, female, Butaritari, December 1879 (Finsch, 1884); POBSP - four (Table 30).

22) Anous tenuirostris Black Noddy

Habitat -- November 1964- Butaritarí present and nesting in vegetated Cocos areas, Kotabu present and nesting in vegetated (Pisonia and and Pemphis) areas, Nabuni present in tall vegetation (Pisonia).

Numbers -- November 1964 - Butaritari 100 estimated, Kotabu 4,000+, Nabuni Island 4.

Status -- Resident breeder. November 1964-Butaritari few nests observed, Kotabu estimated 1800 nests with eggs and chicks, (200+ in one *Pisonia* tree), brood patches present on the 12 birds collected. This is a new atoll breeding record.

Specimen Records-- Other - none; POBSP - twelve (Table 30). This collection represents a new species and specimen record for Makin Atoll.

23) *Gygis alba* White Tern

Habitat -- November 1964 - present in vegetation (*Cocos*, *Pisonia*, *Scaevola*) of Butaritari, Kotabu, Tukerere, and Nabuni.

Numbers -- November 1964 - Butaritari few, Kotabu 200, Tukerere few, Nabuni 3.

Status -- Resident breeder. November 1964 Kotabu few eggs present. This is a new breeding record for the atoll.

Specimen Records -- Other - none; POBSP eight (Table 30). This collection represents a new species and specimen record for Makin Atoll.

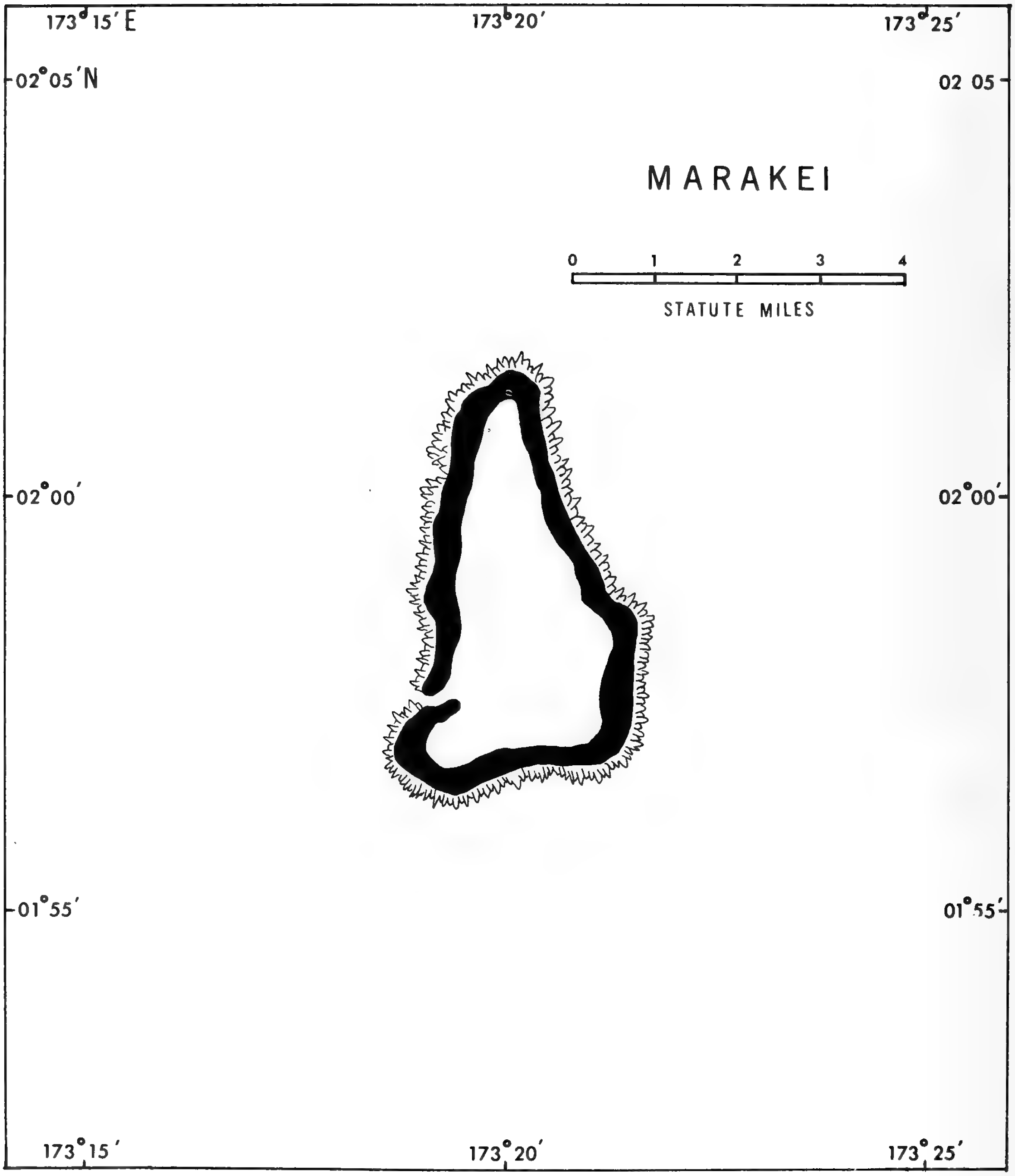
24) *Urodynamis taitensis* New Zealand Cuckoo

Habitat -- 6 December 1879 - present (Finsch, 1880d); June 1894 - present (North, 1894 and 1896); November 1964 - present in the vegetation near the village on Butaritari.

Numbers -- 6 December 1879 - 2 observed on Butaritari (Finsch, 1880d); 1 June 1894 2 collected (North, 1894 and 1896); November 1964 - Butaritari 1 observed.

Status -- Migrant.

Specimen Records -- Other - two (Table 31); POBSP - none.


173° 15′ E
173° 20′
173° 25′
02° 05′ N
02 05
MARAKEI
0
1
2
3
4
STATUTE MILES
02° 00′
02° 00′
01° 55′
01° 55′
173° 15′
173° 20′
173° 25′

MARAKEI ATOLL

Location: 01°48' N x 173°20' E.

Shape and Size: Triangular; East coast - five miles long; West coast - five miles long; South coast-three miles long; Number of islands - one (continuous land rim except for a passageway on the west coast); Total land area - 3.94 square miles; Total lagoon area - 7.57 square miles (Mason *in* Freeman, 1951).

Soil: Beach - rocky (eastern) and sandy (western) with some rock boulders (Agassiz, 1903).

Vegetation: Mainly *Cocos* (Agassiz, 1903); five species listed by Catala (1957).

Climate: Moderately wet, rainfall averages 71.17 inches yearly; Air temperature averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 1,536 (Catala, 1957).

Scientific Visits: Otto Finsch (1884) - December 1879; "Albatross" Tropical Pacific Expedition - 1899;February 1953 to February 1957 - various dates by Peter Child (1960).

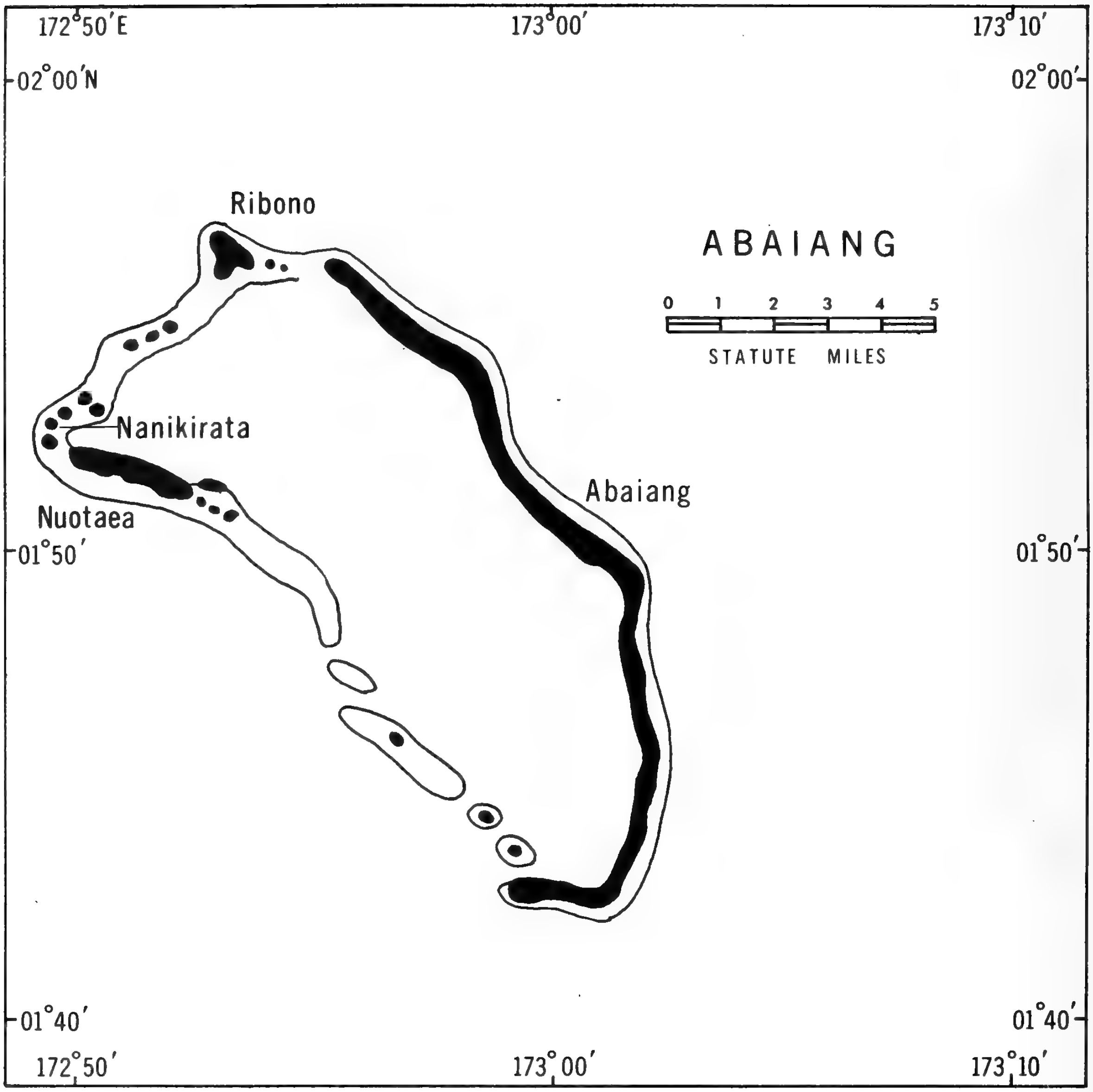
Avifauna: Eleven species of birds are known from Marakei Atoll. [Note: Another species (*Ducula oceanica*) was listed by Wiglesworth (1891), but he subsequently (1893) corrected his error.] These include 4 seabirds, 5 shorebirds, 1 heron, and 1 domestic fowl. One species has been recorded as breeding; 5 additional species are potential breeders.

The 11 known species of birds from Marakei Atoll are listed in the following checklist. The source material includes: (1) Wiglesworth, 1893; (2) Child 1960; and (3) Finsch, 1884. These sources are indicated in the checklist by their corresponding numbers.

Marakei Atoll Avifauna Checklist

	Species	Status	Source
1)	*Egretta sacra*	Resident breeder ?	1, 2
2)	*Gallus gallus*	Introduced breeder ?	2
3)	*Pluvialis dominica*	Migrant	2
4)	*Numenius tahitiensis*	Migrant	2
5)	*Limosa lapponica*	Migrant	2
6)	*Heteroscelus incanum*	Migrant	2
7)	*Arenaria interpres*	Migrant	2
8)	*Thalasseus bergii*	Resident breeder ?	2
9)	*Anous stolidus*	Resident breeder, December (eggs, young)	2, 3,
10)	*Anous tenuirostris*	Resident breeder ?	2
11)	*Gygis alba*	Resident breeder ?	2

One bird specimen is known from Marakei Atoll, but its present deposition is unknown. Finsch (1884) listed an adult male, *Anous stolidus*, with a nest, presumably collected 4 December 1879.



172°50′E
173°00′
173°10′
02°00′N
02°00′
Ribono
ABAIANG
0 1 2 3 4 5
STATUTE MILES
Nanikirata
Abaiang
Nuotaea
01°50′
01°50′
01°40′
01°40′
172°50′
173°00′
173°10′

ABAIANG ATOLL

Location: 01°41' N x 172°58' E.

Shape and Size: An irregular oval atoll; Length - 16 miles; Width - about 8 miles; Number of islands - 4 plus several islets (principal land rim on eastern face); Total land area - 11.05 square miles; Total lagoon area - 89.78 square miles (Agassiz, 1903; Mason *in* Freeman, 1951).

Soil: Beach (ocean) - rocky and coarse sandy areas; Beach (lagoon) - fine sand with some rocky areas (Agassiz, 1903).

Vegetation: Primary cover - *Cocos*; Catala (1957) lists 13 species.

Climate: Moderately wet, rainfall averages 73.58 inches yearly; Air temperature averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 2,467 (Catala, 1957).

Scientific Visits: Andrew Garrett (Greenway, 1952)- September-October 1859; Otto Finsch (1880d)-November-December 1879; "Albatross" Tropical Pacific Expedition -1900; Child (personal communication, August 1965) did not visit Abaiang during February 1953 to February 1956 as his 1960 paper implies.

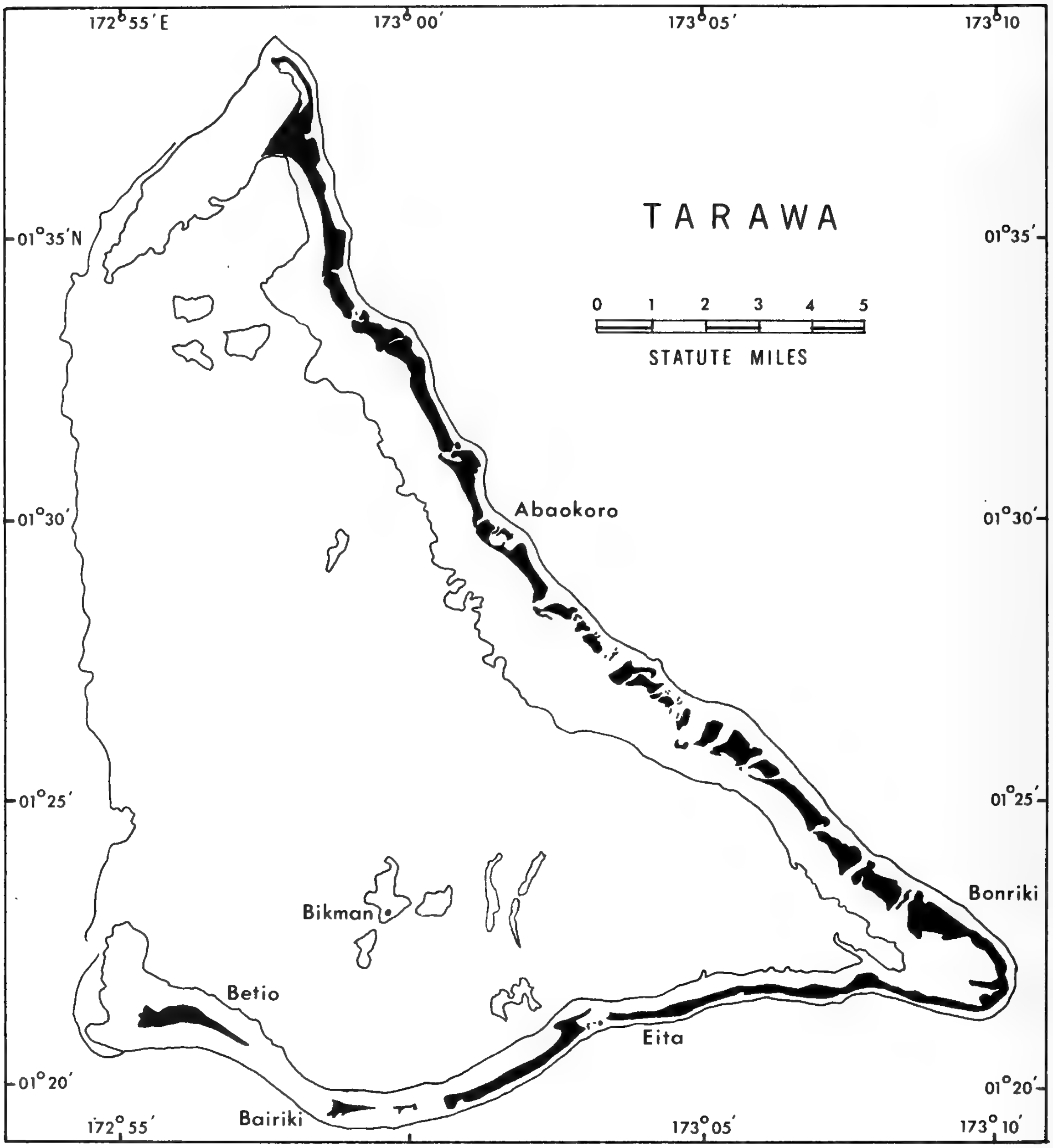
Avifauna: Two bird species have been recorded as occurring on Abaiang Atoll. Child (1960) reported that "... a possible nesting site [of *Sula sula* exists] at Bakatonotoro (Abaiang) ...", but he (Child, personal communication, August 1965) did not visit Abaiang Atoll. Although Finsch (1880d) visited Abaiang Atoll, he did not list any bird species specifically from the atoll.

Greenway (1952) reported that Andrew Garrett collected one or two specimens of every bird at Abaiang during his 1859 visit. Nothing is known of the present whereabouts of these specimens (see also next paragraph). Greenway further reported that Garrett obtained a tail feather of what he thought was (although he never saw it) a species of hawk. Four species of hawks occur as visitors to the Western Pacific (Marianas, Carolines, Palaus), however, none have been taken from either the Marshalls or the Gilberts. Since he did not see this "hawk," the feather that he found is more likely from the New Zealand Cuckoo, *Urodynamis taitensis*, which commonly occurs in the Gilberts. Both this cuckoo and a great many hawks have barred tails; thus Garrett could have easily confused the two.

A specimen of an immature, female flightless rail, *Tricholimnas sylvestris* (= *conditicus*), was supposedly collected by Andrew Garrett from Abaiang in 1859. It was described as a new species (MCZ #21943)

by Peters and Griscom (1928); however, Greenway (1952) presented evidence that *I. conditicus* should be a synonym of *T. sylvestris*, which is known from Lord Howe Island. He presented further evidence that the "*I. conditicus*" specimen was not collected at Abaiang. I agree with Greenway's conclusions that this rail was probably collected at Lord Howe Island and not at Abaiang.

348-415 O-69—16.



172°55′E
173°00′
173°05′
173°10
TARAWA
0 1 2 3 4 5
STATUTE MILES
01°35′N
01°35′
Abaokoro
01°30′
01°30′
01°25′
01°25′
Bonriki
Bikman
Betio
Eita
01°20′
01°20′
Bairiki
172°55′
173°05′
173°10′

TARAWA ATOLL

Location: 01°25' N x 173°00' E.

Shape and Size: An isosceles triangle, east-west base 17 miles, southeast-northwest face 21 miles, west face 20 miles; Number of islands - 9 large and many small islets (on east and south faces only); Total land area - 7.73 square miles; Total lagoon area - 132.67 square miles (Agassiz, 1903; Mason in Freeman, 1951; and Doran, 1959).

Soil: Beach (ocean) - rocky and sandy area; Beach (lagoon) - sandy but some rocky areas, tidal flats in many areas (Agassiz, 1903; see also Catala, 1957).

Vegetation: Mostly Cocos, but 103 species listed by Catala (1957) (see also Doran, 1959).

Climate: Moderately wet, rainfall averages 64.02 inches annually; Air temperature averages 83 - 85° F., Wind - prevailing from east (Sachet, 1957; Doran, 1959).

Human Population: 1950 - 3,790 (Catala, 1957); 1956 - 4,851 (U.S. Navy, 1966).

Scientific Visits: Otto Finsch (1880d, 1884)- November-December 1879; 1900 "Albatross" Tropical Pacific Expedition; Peter Child (1960; personal communication, August 1965)- May 1953 to January 1956; R. O. Morris (1963)- 12 July 1963.

Avifauna: Nineteen species of birds are known from Tarawa Atoll. Six of these species are seabirds, 8 are shorebirds, 2 are ducks, 1 is a heron, 1 a cuckoo, and 1 a domestic fowl. Of these, 8 species are potential breeders, however, only 4 species are known to breed.

The following list presents the known bird species from Tarawa Atoll which have been recorded by (1) Finsch, (a) 1880d, (b) 1884; (2) Wiglesworth, 1893; (3) Townsend and Wetmore, 1919; (4) Child, 1960; (5) Morris, 1963; and (6) POBSP, band return. These sources are indicated in the checklist by corresponding numbers and letters. The one species marked by an asterisk is a new island species record.

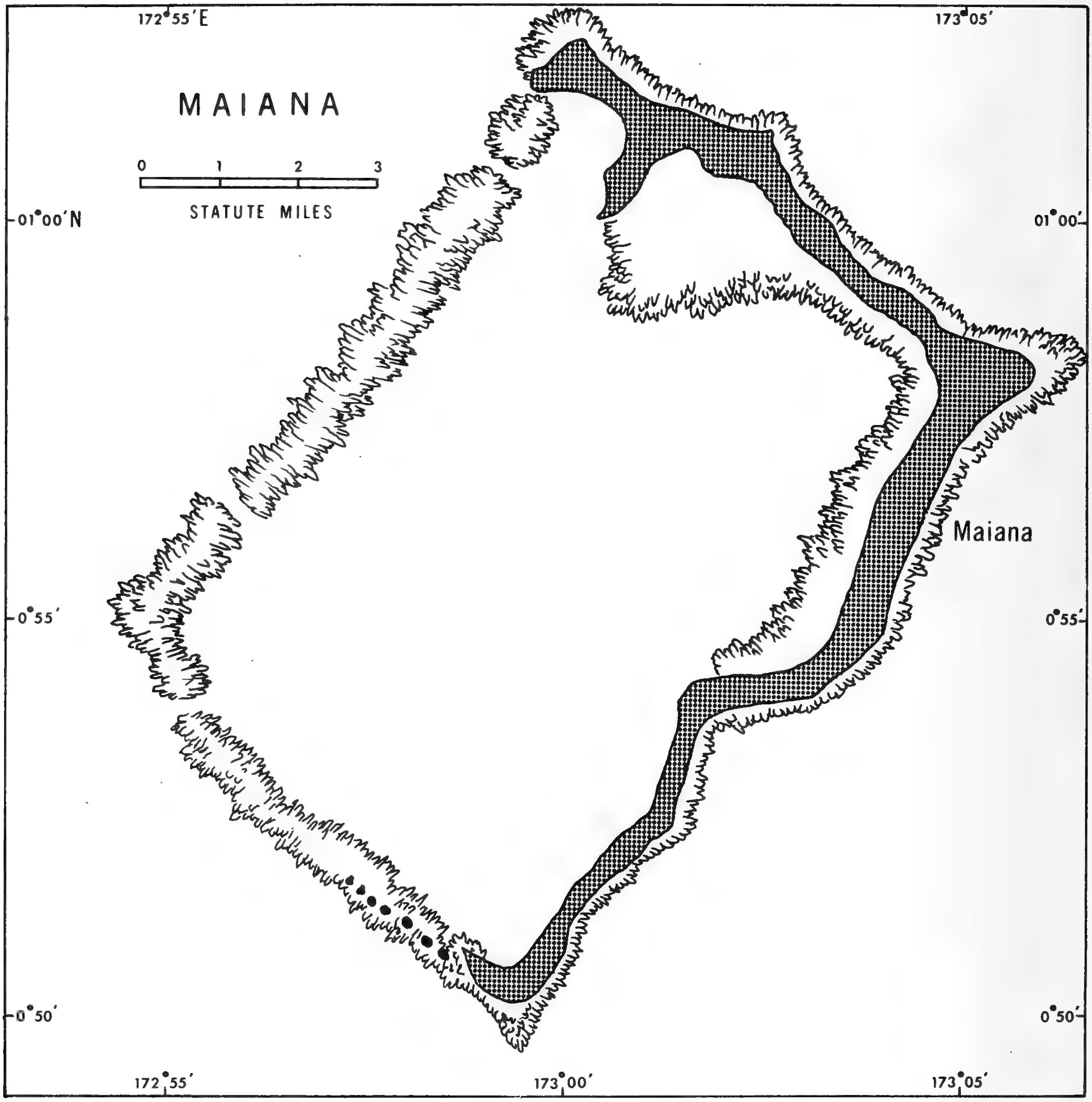
Tarawa Atoll Avifauna Checklist

	Species	Status	Source
1)	Fregata ariel*	Resident breeder ?	1b
2)	Egretta sacra	Resident breeder November to June	1a,3, 4, 5, 6
3)	Anas platyrhynchos	Accidental	5
4)	Anas clypeata	Migrant	5
5)	Gallus gallus	Introduced breeder ?	5
6)	Pluvialis dominica	Migrant	3, 5
7)	Numenius tahitiensis	Migrant	1a,5
8)	Limosa lapponica	Migrant	1a,5
9)	Heteroscelus brevipes	Migrant	5
10)	Heteroscelus incanum	Migrant	4, 5, 6
11)	Arenaria interpres	Migrant	2, 4, 5
12)	Crocethia alba	Migrant	5
13)	Erolia acuminata	Migrant	5
14)	Sterna sumatrana	Resident breeder, January to September	5, 6
15)	Thalasseus bergii	Resident breeder, May (immature)	1a,5, 6
16)	Anous stolidus	Resident breeder, December (eggs to young)	1a,5, 6
17)	Anous tenuirostris	Resident breeder ?	5, 6
18)	Gygis alba	Resident breeder ?	5, 6
19)	Urodynamis taitensis	Migrant	5

Twelve specimens of 4 species have been collected from Tarawa Atoll. Finsch (1884) collected a male Arenaria interpres in winter plumage from Tarawa Atoll on 12 December 1879; its present deposition is unknown. Townsend, aboard the "Albatross," collected 11 specimens at Tarawa Atoll on 3 January 1900 (Townsend and Wetmore, 1919). Townsend's specimens are listed in Table 32.

Table 32. Bird specimens collected from Tarawa Atoll.

Species	Museum		Age	Sex	Status	Collector
Egretta sacra	USNM	212178	A	♂	Skin	Townsend
" "	"	212179	A	♂	"	"
Pluvialis dominica	"	212223	A	♂	"	"
" "	"	212224	A	♂	"	"
" "	"	212225	A	♂	"	"
" "	MCZ	81924	A	♂	"	"
Arenaria interpres	USNM	212211	A	♀	"	"
" "	"	212212	A	♂	"	"
" "	"	212213	A	♂	"	"
Heteroscelus incanum	"	212186	A	♀	"	"
" "	"	212187	A	♂	"	"



172°55′E
173°05′
MAIANA
0
1
2
3
STATUTE MILES
01°00′N
01°00′
Maiana
0°55′
0°55′
0°50′
0°50′
172°55′
173°00′
173°05′

MAIANA ATOLL

Location: 00°55' N. x 173°00' E.

Shape and Size: Rectangular-shaped; northeast and southwest sides - 7 miles; northwest and southeast sides - 11 miles; Number of islands - 8 (one main island - 1/2 to 2 miles wide); Total land area - 10.39 square miles; Total lagoon area - 38 square miles (Mason in Freeman, 1951).

Soil: Beach (ocean) - rocky with some sandy area; Beach (Lagoon) - sandy, extensive sand flats at northwest corner of Maiana Island at low tide; Inland - organic material mixed with sand over coral fragments; No inland ponds; Water in well about 10' below ground surface.

Vegetation: Primary species - *Cocos*; *Pandanus* also present.

Climate: Moderately dry, rainfall averages 57.32 inches yearly. Air temperature averages 83-84°F;Wind- prevailing from east (Sachet, 1957).

Human Population: 1950 - 1,238 (Catala, 1957).

Scientific Visits: Peter Child (1960) - February 1953 to February 1956; POBSP - 16-17 November 1964.

Avifauna: Fifteen bird species are known from Maiana Atoll. These include 7 seabirds, 6 shorebirds, 1 heron, and 1 domesticated fowl. Only 1 species is a known breeder, eight others are possible breeders, and 6 are migrants.

Fifteen species are listed in the following checklist, which was derived from: (1) POBSP, (a) 1964, (b) band return; and (2) Child, 1960. These sources are indicated in the checklist by their corresponding numbers and letters. The four species marked by a single asterisk are new species records for Maiana Atoll; the single species marked by double asterisks is a new atoll breeding record.

Maiana Atoll Avifauna Checklist

	Species	Status	Source
1)	*Fregata minor**	Resident breeder ?	1a
2)	*Fregata ariel**	Resident breeder ?	1b
3)	*Egretta sacra*	Resident breeder ?	1a, 2
4)	*Gallus gallus*	Introduced breeder ?	1a, 2
5)	*Pluvialis dominica*	Migrant	1a, 2
6)	*Numenius phaeopus**	Migrant	1a
7)	*Numenius tahitiensis*	Migrant	1a, 2
8)	*Limosa lapponica*	Migrant	1a, 2

	Species	Status	Source
9)	*Heteroscelus incanum*	Migrant	la, 2
10)	*Arenaria interpres*	Migrant	la, 2
11)	*Sterna sumatrana**	Resident breeder ?	la
12)	*Thalasseus bergii*	Resident breeder ?	la, 2
13)	*Anous stolidus*	Resident breeder**	la, 2
14)	*Anous tenuirostris*	Resident breeder ?	la, 2
15)	*Gygis alba*	Resident breeder ?	la, 2

POBSP personnel have collected 38 specimens of 8 species (Table 33). Of these 8 species, 2 are specimen records of species not previously known from Maiana Atoll; the other 6 represent the first specimen confirmation of species previously known only from sight records. No other specimens are known from Maiana Atoll.

Table 33. Bird specimens collected by POBSP from Maiana Atoll.

Species	Museum		Sex	Age	Location	Date	Status	Collector
Pluvialis dominica	USMN	494722	♂	-	Maiana I.	11-16-64	Skin	Clapp
" "	"	494723	?	-	"	"	"	"
" "	"	494724	♂	-	"	"	"	"
Numenius phaeopus	"	494841	♀	-	"	"	"	"
Limosa lapponica	"	494836	?	-	"	"	"	"
" "	"	543436	♀	-	"	"	"	"
Heteroscelus incanum	"	494907	♂	-	"	"	"	"
" "	"	494908	♀	-	"	"	"	"
Arenaria interpres	"	494778	♂	-	"	"	"	Huber
" "	"	494779	♂	-	"	"	"	"
" "	"	494780		-	"	"	"	Clapp
" "	"	494781	♂	-	"	"	"	"
" "	"	494782	♀	-	"	"	"	"
" "	"	494783	♀	-	"	"	"	"
" "	"	494784	♀	-	"	"	"	"
" "	"	494785	♀	-	"	"	"	"
" "	"	494786	♀	-	"	"	"	"
" "	"	494787	♂	-	"	"	"	"
" "	"	502905	-		"	"	Alc.	"
" "	"	502906	-	-	"	"	"	"
" "	"	502907	-	-	"	"	"	"
" "	"	502908	-	-	"	"	"	"
" "	"	502909	-	-	"	"	"	"
" "	"	502910	-	-	"	"	"	"
" "	"	502911	-	-	"	"	"	"
" "	"	502912	-	-	"	"	"	"
" "	"	502913	-	-	"	"	"	"
" "	"	502914	-	-	"	"	"	"
" "	"	502915	-	-	"	"	"	"

Table 33 (cont.). Bird specimens collected by POBSP from Maiana Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Sterna sumatrana	USMN 494605	♀	-	Maiana I.	11-16-64	Skin	Clapp
" "	" 494606	♂	-	"	11-17-64	"	"
Anous stolidus	" 494675	♀	-	"	"	"	Amerson
Anous tenuirostris	" 494568	♂	-	"	"	"	Clapp
" "	" 494569	♂	-	"	"	"	Amerson
" "	" 494570	♂	-	"	"	"	Clapp
" "	" 494571	♂	-	"	"	"	"
" "	" 494572	♀	-	"	"	"	"
" "	" 494573	♀	-	"	"	"	"

Species Accounts

1) *Fregata minor* Great Frigatebird

Habitat -- November 1964 - flying over island.

Numbers -- November 1964 - 2 observed.

Status -- Resident breeder? November 1964 - no breeding observed. It is doubtful that this species breeds at Maiana Atoll due to the lack of suitable breeding sites. The small island at the south end of the atoll might be suitable, however.

Specimen Records -- None. This observation represents a new species sight record for Maiana Atoll.

2) *Fregata ariel* Lesser Frigatebird

See Banded Bird Recaptures, Appendix A.

3) *Egretta sacra* Reef Heron

Habitat -- February 1953 to February 1956 - "... on all islands of the Gilbert [Islands] ..." (Child, 1960); November 1964 - on rocky beaches and exposed reef areas.

Numbers -- November 1964 - Maiana Island 6 or 7 seen.

Status -- Resident breeder? February 1953 to February 1956 - "The nesting season [over the entire Gilbert-Ellice Group] lasts from November to June." (Child, 1960); November 1964 - no breeding activity observed.

Specimen Records -- None.

4) Gallus gallus Domestic Chicken

Habitat -- February 1953 to February 1956 - "... common on all islands where there are native villages ..." (Child, 1960); November 1964 - present in and around the villages.

Numbers -- February 1953 to February 1956 - see under Habitat; November 1964 - no estimate made but chickens were very frequently seen.

Status -- Introduced breeder? November 1964 - breeding not observed but this species probably nests in and around the villages.

Specimen Records -- None.

5) Pluvialis dominica Golden Plover

Habitat -- February 1953 to February 1956 - "... on tidal flats or near the water's edge on the beach; [also] in open grassy areas or among the coconut clearings ..." (Child, 1960); November 1964 - on the mud flats, sandy beaches, and grassy areas around the villages.

Numbers -- February 1953 to February 1956 - "... although a few may be seen all the year round the greatest numbers are present from October to April." (Child, 1960); November 1964 - Maiana Island 100's present.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - three (Table 33). Although Child reported Golden Plover from Maiana Atoll, this is a new specimen record for the atoll.

6) Numenius phaeopus Whimbrel

Habitat -- November 1964 - on rocky ocean beach of Maiana Island.

Numbers -- November 1964 - Maiana Island, 1 seen and collected.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - one (Table 33). This is a new species and specimen record for Maiana Atoll.

7) Numenius tahitiensis Bristle-thighed Curlew

Habitat -- February 1953 to February 1956 - Gilbert Islands, tidal mud flats or on the reef at low tide, occasionally seen inland (Child, 1960); November 1964 - present on tidal flats, exposed reef areas, and ocean beaches.

Numbers -- February 1953 to February 1956 - "occasional birds may be seen on all [Gilbert] islands at any time of the year but are most common from about late August to April ..." (Child, 1960); November 1964 - Maiana Island 12.

Status -- Migrant.

Specimen Records -- None.

8) Limosa lapponica Bar-tailed Godwit

Habitat -- February 1953 to February 1956 - "... seen chiefly on tidal mud flats, singly or in small groups; at high tide larger flocks of up to 50 birds may be found gathered on a dry spit or islet." [Note: Child uses this as a habitat description for this species in the entire Gilbert Islands] (Child, 1960); November 1964 - present on the tidal flats.

Numbers -- February 1953 to February 1956 - see under Habitat (Child, 1960); November 1964 - Maiana Island 2 observed and collected.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - two (Table 33). This collection constitutes a new specimen record for Maiana Atoll.

9) Heteroscelus incanum Wandering Tattler

Habitat -- February 1953 to February 1956 - "... generally feeds alone on the edge of the tide or on mud flats ... often wades out into shallow water ... at high tide larger groups rest together among the rocks or in the shade of mangrove bushes." [Note: Habitat description is for all of the Gilbert Islands.] (Child, 1960); November 1964 - Maiana Island on tidal flats and sandy and rocky ocean beaches.

Numbers -- February 1953 to February 1956 - "... well-known on all [Gilbert] islands ..." (Child, 1960); November 1964 - Maiana Island 59+ estimated.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - two (Table 33). This collection represents a new specimen record for Maiana Atoll.

10) Arenaria interpres Ruddy Turnstone

Habitat -- February 1953 to February 1956 - present (Child, 1960); November 1964 - present on tidal flats and sandy beaches of Maiana Island.

Numbers -- February 1953 to February 1956 - "... is the commonest of the Arctic visitors ... usually being seen in groups of 10 to 100 or more ..." (Child, 1960); November 1964 - Maiana Island 100's observed.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - twenty-one (Table 33). Although Ruddy Turnstones have previously been observed at Maiana Atoll, this collection represents a new specimen record from the atoll.

11) Sterna sumatrana Black-naped Tern

Habitat -- November 1964 - over lagoon and tidal flats (especially at north end of the atoll) at Maiana Island.

Numbers -- November 1964 - Maiana Island 6, lagoon 1.

Status -- Resident breeder? November 1964 - no nests observed, however, adults were observed with well-fledged young.

Specimen Records -- Other - none; POBSP - two (Table 33). This is a new species and specimen record for Maiana Atoll.

12) Thalasseus bergii Crested Tern

Habitat -- February 1953 to February 1956 - "... are said to nest in small colonies on sand or gravel bars ..." (Child, 1960) [Note: This is Child's habitat description for this species in the Gilbert Islands]; November 1964- present over lagoon and roosting on exposed reef and sand flats at low tide.

Numbers -- February 1953 to February 1956 - "... appears to be present in small numbers on most islands [in the Gilbert Islands]." (Child, 1960); November 1964 - Maiana Island (northern end) 15+.

Status -- Resident breeder? February 1953 to February 1956 - Child (1960) reports that "[in the Gilbert Islands] it is said that one egg is laid between December and February."; November 1964 - not breeding, but both adults and flying immatures present suggesting that this species breeds on Maiana Atoll.

Specimen Records-- None.

13) Anous stolidus Brown Noddy

Habitat -- November 1964 - roosting and nesting in Cocos trees on Maiana Island.

Numbers -- February 1953 to February 1956 - "... fairly common on all islands of the Colony." (Child, 1960); November 1964 - Maiana Island 100's present.

Status -- Resident breeder. November 1964 - few adults seen on nests at base of palm fronds on the northern end of Maiana, said by natives to nest commonly on island at south end of the atoll. This is a new breeding record.

Specimen Records -- Other - none; POBSP - one (Table 33). This is a new specimen record for Maiana Atoll.

14) *Anous tenuirostris* Black Noddy

Habitat -- November 1964 - Maiana Island (especially the northern end) roosting in *Cocos* trees.

Numbers -- February 1953 to February 1956 - "... listed in large numbers on all islands visited ..." (Child, 1960); November 1964 - Maiana Island 100's present.

Status -- Resident breeder? November 1964 - no nests observed, however, three of six adults collected had brood patches present suggesting they were nesting somewhere on the atoll. The natives said they nested in trees on a small island at the south end of the atoll but this could not be verified.

Specimen Records -- Other - none; POBSP - six (Table 33). This collection represents a new specimen record for Maiana Atoll.

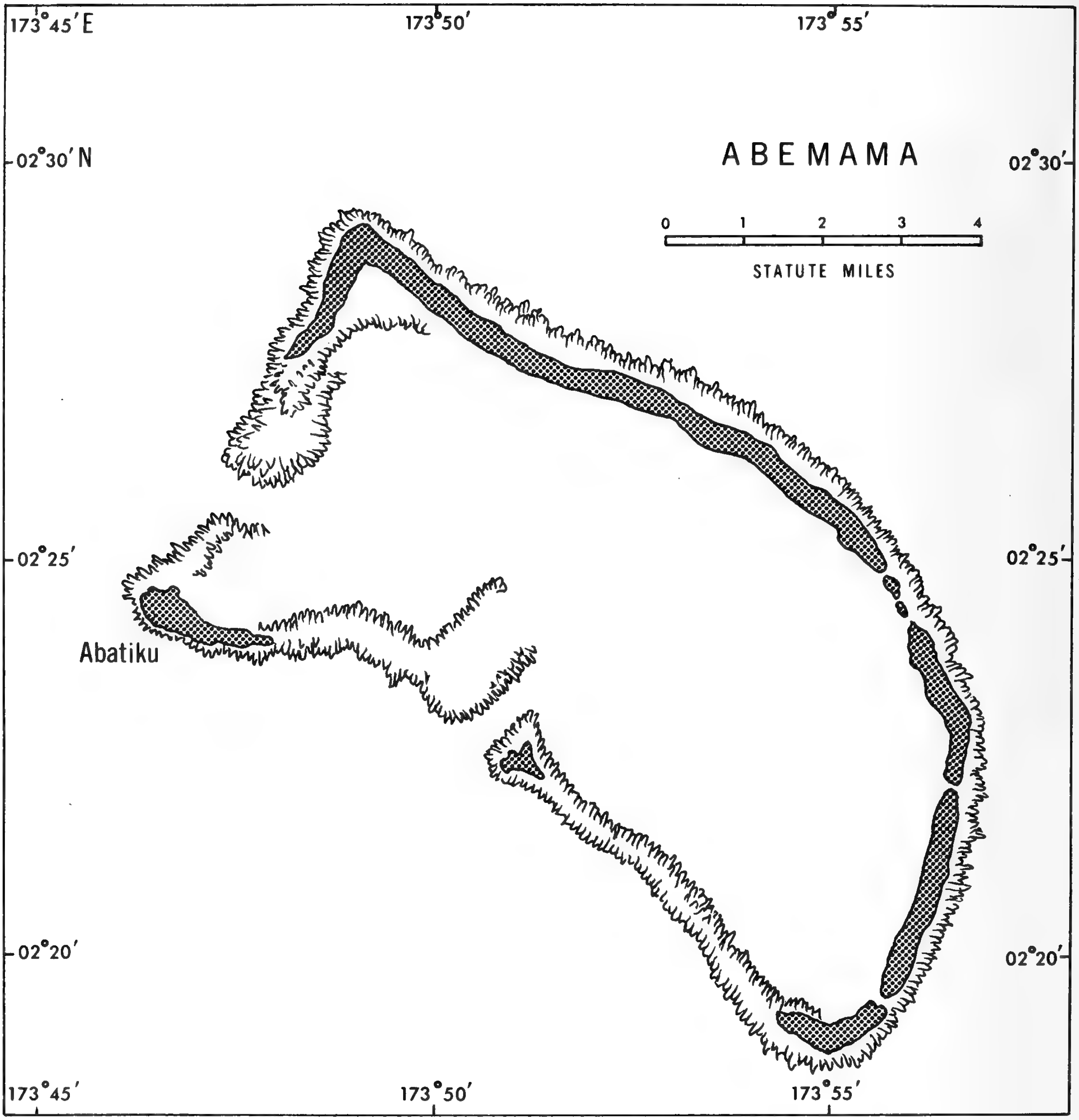
15) *Gygis alba* White Tern

Habitat -- November 1964 - flying about Maiana Island.

Numbers -- February 1953 to February 1956 - "... fairly common on all islands ..." (Child, 1960); November 1964 - Maiana Island few observed.

Status -- Resident breeder? November 1964 - no breeding activity observed, however, this species probably nests on Maiana Atoll.

Specimen Records -- None.



173°45′E
173°50′
173°55′
02°30′N
ABEMAMA
02°30′
0
1
2
3
4
STATUTE MILES
02°25′
02°25′
Abatiku
02°20′
02°20′
173°45′
173°50′
173°55′

ABEMAMA ATOLL

Location: 00°21' N x 173°51' E.

Shape and Size: An irregular triangle; Eastern coast - convex, 14 miles long; Northwestern coast - straight, 6 miles long; Southwestern coast - slightly concave, 11 miles; Number islands - 8 (eastern coast almost continuous strip one-half mile wide); Height - 6 to 12 feet; Total land area - 6.57 square miles; Total lagoon area - 51.12 square miles (H. O. Chart 0122; Mason in Freeman, 1951; Doran, 1959).

Soil: Beaches - sandy and rocky (see Agassiz, 1903 for description).

Vegetation: Mainly *Cocos*, *Pandanus*, and *Pisonia* (Agassiz, 1903). Fourteen species listed by Catala (1957).

Climate: Moderately dry, rainfall averages 53.04 inches annually; Air temperature averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 1,498 (Catala, 1957).

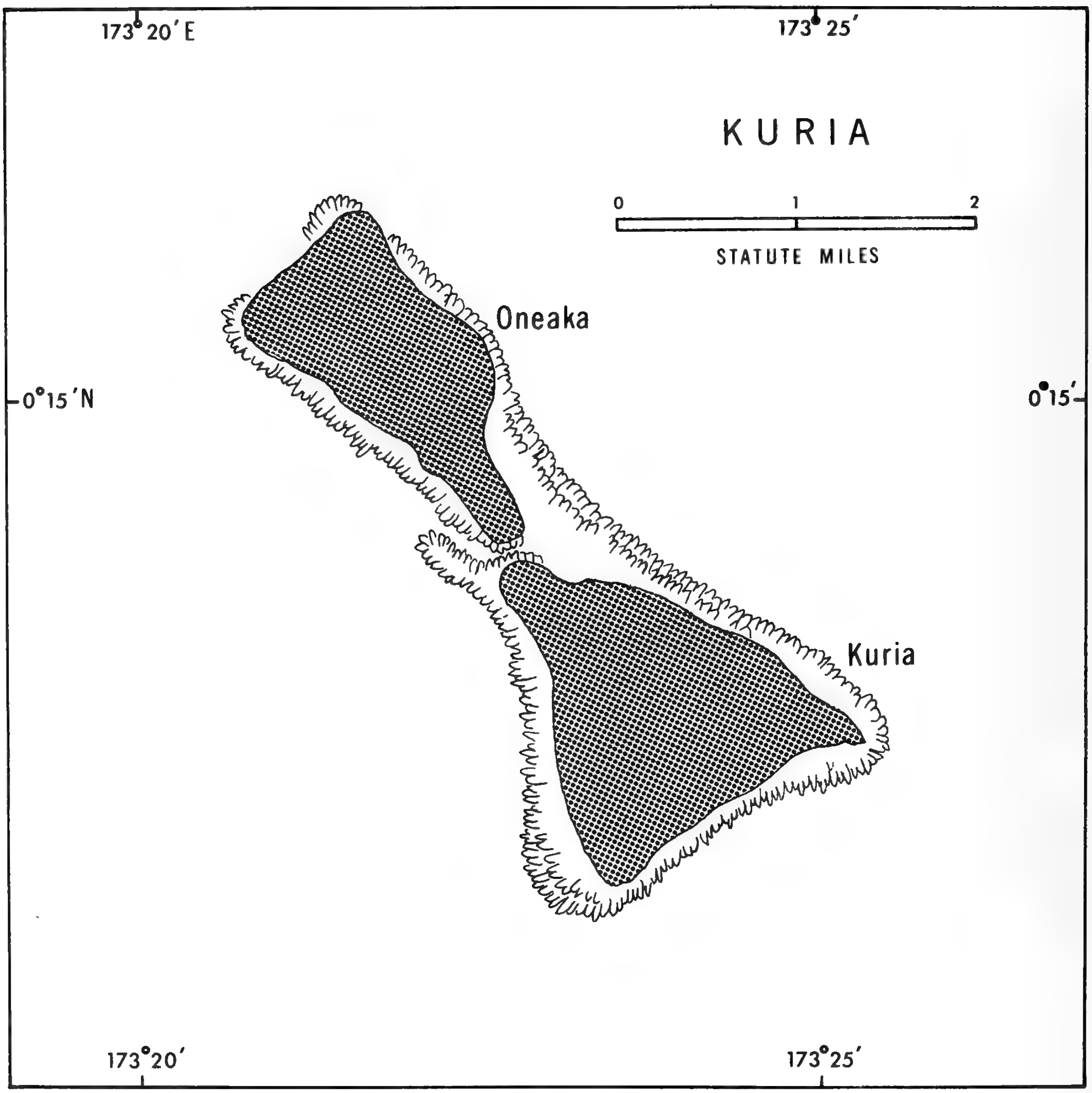
Scientific Visits: "Albatross" Tropical Pacific Expedition - 1899; Peter Child (1960) - February 1953 to February 1956.

Avifauna: Thirteen species of birds are presently known from Abemama Atoll. These include 4 seabird species, 5 shorebird species, 1 heron, 2 doves, and 1 domestic fowl. Eight species are potential breeders, however, only 1 (an introduced species) is known to breed. No bird specimens are known from the atoll.

The 13 known species of birds recorded from Abemama Atoll by Child (1960) are presented in the following checklist.

Abemama Atoll Avifauna Checklist

	Species	Status
1)	*Egretta sacra*	Resident breeder?
2)	*Gallus gallus*	Introduced breeder ?
3)	*Pluvialis dominica*	Migrant
4)	*Numenius tahitiensis*	Migrant
5)	*Limosa lapponica*	Migrant
6)	*Heteroscelus incanum*	Migrant
7)	*Arenaria interpres*	Migrant
8)	*Thalasseus bergii*	Resident breeder ?
9)	*Anous stolidus*	Resident breeder ?
10)	*Anous tenuirostris*	Resident breeder ?
11)	*Gygis alba*	Resident breeder
12)	*Gallicolumba erythroptera* (Ground Dove)	Introduced breeder
13)	*Gallicolumba stairii* (Friendly Ground Dove)	Introduced breeder ?


173°20′E
173°25′
KURIA
0
1
2
STATUTE MILES
Oneaka
0°15′N
0°15′
Kuria
173°20′
173°25′

KURIA ATOLL

Location: 00°14' N x 173°25' E.

Shape and Size: Dumbbell-shaped pair of islands (each island forming an end): Total length - 4 miles; Number of islands - 2; Oneaka Island (northern) - length 2 miles, widest point 1-1/2 miles; Kuria Island (southern) - length 2 miles, widest point 2 miles; Total land area - 4.98 square miles; No lagoon; however, extensive shallow area extends west and northwest of the islands (H.O. Chart 0122; Mason in Freeman, 1951).

Soil: Beach (windward side) - rocky but some sandy areas; Beach (leeward side) - mostly sandy, some rocky areas; Inland - organic matter mixed with sand over coral gravel; Inland lagoons present on both Oneaka and Kuria Islands.

Vegetation: Primary species - *Cocos*, scattered *Pisonia*, *Pemphis*, and *Pandanus*; vegetation in uninhabited areas dense.

Climate: Moderately dry, average rainfall 48.37 inches yearly; Air temperature averages 83-84°F;Wind- prevailing from east (Sachet, 1957).

Human Population: 1950 - 530 (Catala, 1957).

Scientific Visits: Peter Child (1960) - February 1953 to February 1956 - various dates; POBSP - 17-19 November 1964.

Avifauna: Seventeen species of birds are presently known from Kuria Atoll. These include 7 seabirds, 7 shorebirds, 1 heron, 1 pigeon, and 1 domesticated fowl. Five of these species are known breeders, 5 others are possible breeders, and 7 are migrants.

Seventeen species are listed in the following checklist which was derived from: (1) POBSP, 1964; (2) Child, 1960 ; (3) Richardson and Fisher, 1950; and (4) Ashmole, 1963. These sources are referred to in the checklist by their corresponding numbers. The five species marked by a single asterisk are new species records for Kuria Atoll; the three species marked by double asterisks are new atoll breeding records.

348-415 O-69—17

Kuria Atoll Avifauna Checklist

	Species	Status	Source
1)	Fregata minor*	Resident breeder ?	1
2)	Egretta sacra	Resident breeder ?	1, 2
3)	Gallus gallus	Introduced breeder ?	1, 2
4)	Pluvialis dominica	Migrant	1, 2
5)	Numenius phaeopus*	Migrant	1
6)	Numenius tahitiensis	Migrant	1, 2
7)	Limosa lapponica	Migrant	1, 2
8)	Heteroscelus incanum	Migrant	1, 2
9)	Arenaria interpres	Migrant	1, 2
10)	Erolia acuminata*	Migrant	1
11)	Sterna sumatrana*	Resident breeder ?	1
12)	Sterna fuscata	Resident breeder	1, 2, 3, 4
13)	Thalasseus bergii	Resident breeder	1, 2
14)	Anous stolidus	Resident breeder**	1, 2
15)	Anous tenuirostris	Resident breeder**	1, 2
16)	Gygis alba	Resident breeder**	1, 2
17)	Ducula oceanica*	Resident breeder ?	1

POBSP personnel have collected 36 specimens of 10 species (Table 34). Of these 10 species, 3 are specimen records of species not previously known from the atoll; the other 7 represent the first specimen confirmation of species previously known only from sight records. No other specimens are known from Kuria Atoll.

Table 34. Bird specimens collected by POBSP from Kuria Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Egretta sacra	USMN 494863	♀	-	Kuria I.	11-18-64	Skin	Huber
Pluvialis dominica	" 494725	♀	-	"	"	"	Amerman
" "	" 494726	♂	-	"	"	"	"
Numenius tahitiensis	" 494828	♂	-	"	"	"	Clapp
Arenaria interpres	" 494788	♀	-	"	"	"	Amerman
" "	" 494789	♂	-	"	"	"	Clapp
Erolia acuminata	" 494810	♀	-	Oneaka	"	"	Huber
" "	" 494811	♀	-	"	"	"	"
" "	" 494812	♂	-	"	"	"	"
" "	" 494813	♂	-	"	"	"	"
Sterna sumatrana	" 494607	♀	Imm	"	"	"	"
" "	" 494608	-	A	"	"	"	Amerman
Anous stolidus	" 494676	♂	-	"	11-17-64	"	Amerson
" "	" 494677	♂	-	"	"	"	"
" "	" 494678	♀	-	"	"	"	Clapp
" "	" 494679	♀	-	"	"	"	"
" "	" 494680	♀	-	"	"	"	Huber
" "	" 494681	♀	-	"	"	"	Amerson
" "	" 494682	♂	-	"	"	"	Huber
" "	" 494673	♂	-	"	11-18-64	"	"
Anous tenuirostris	" 494574	♂	-	Kuria I.	11-17-64	"	Clapp
" "	" 494575	♀	-	"	"	"	"
" "	" 494576	♀	-	"	"	"	"
" "	" 494577	♂	-	"	"	"	Amerson
" "	" 494578	♂	-	"	"	"	Clapp
" "	" 494579	♂	-	"	11-18-64	"	"
" "	" 494580	♀	-	"	"	"	"
" "	" 494581	♀	-	Oneaka	"	"	Huber
" "	" 494582	♀	-	"	"	"	"
Gygis alba	" 494645	♀	-	Kuria I.	11-17-64	"	"
" "	" 494646	♂	-	"	"	"	"
" "	" 494647	♀	-	"	"	"	Clapp
" "	" 502916	-	A	"	"	Alc.	"
" "	" 502917	-	-	"	"	"	"
Ducula oceanica	" 494815	?	-	"	"	Skin	Huber
" "	" 494816	♀	-	"	11-18-64	Skin and skeleton	Amerson

Species Accounts

1) Fregata minor Great Frigatebird

Habitat -- November 1964 - Oneaka observed just offshore.

Numbers -- November 1964 - Oneaka 1.

Status -- Resident breeder? May, but probably doesn't breed on the atoll.

Specimen Records -- None. This observation is a new species sight record for Kuria Atoll.

2) Egretta sacra Reef Heron

Habitat -- November 1964 - exposed reef (at low tide, sandbars and inland pond areas).

Numbers -- February 1953 to February 1956 - "... is a familiar sight on all islands of the Gilbert [Islands] ..." (Child, 1960); November 1964 - Oneaka 5, Kuria 5-6.

Status -- Resident breeder? November 1964 - no nests observed, however, a collected female had a large ovum and a very enlarged oviduct indicating that she was nesting.

Specimen Records -- Other - none; POBSP - one (Table 34). This collection represents a new specimen record from Kuria Atoll.

3) Gallus gallus Domestic Chicken

Habitat -- November 1964 - present in and around the villages on both Oneaka and Kuria.

Numbers -- February 1953 to February 1956 - "... common on all [Gilbert] islands where there are native villages ..." (Child, 1960); November 1964 - estimate not made but chickens were frequently observed.

Status -- Introduced breeder? November 1964 - breeding not observed, but this species probably nests in and around the villages.

Specimen Records -- None.

4) Pluvialis dominica Golden Plover

Habitat -- November 1964 - Kuria and Oneaka on ocean beaches, inland grassy or open areas, and around inland pond areas.

Numbers -- February 1953 to February 1956 - "... although a few may be seen [in the Gilbert Islands] all the year round the greatest numbers are present from October to April" (Child, 1960); November 1964 - Kuria 25 estimated, Oneaka 25 estimated.

Status -- Migrant.

Specimen Records -- Other - none, POBSP - two (Table 34). This collection constitutes a new specimen record for Kuria Atoll.

5) Numenius phaeopus Whimbrel

Habitat -- 18 November 1964 -- Oneaka on exposed reef at low tide and inland pond areas.

Numbers -- 18 November 1964 - Oneaka 1.

Status -- Migrant.

Specimen Records -- None. This observation is a new species sight record for Kuria Atoll.

6) Numenius tahitiensis Bristle-thighed Curlew

Habitat -- November 1964 - Oneaka and Kuria present on ocean beach, exposed reef at low tide, and inland pond areas.

Numbers -- February 1953 to February 1956 - "occasional birds may be seen on all [Gilbert] islands at any time of the year but are most common from about late August to April ..." (Child, 1960); November 1964 - Kuria 3, Oneaka 3.

Status -- Migrant.

Specimen Records -- Other - none, POBSP - one (Table 34). This is a new specimen record for Kuria Atoll.

7) Limosa lapponica Bar-tailed Godwit

Habitat -- 19 November 1964 - Kuria observed on exposed reef at low tide.

Numbers -- February 1953 to February 1956 - Child (1960) does not mention Kuria Atoll specifically but says of L. lapponica - "fairly common in the Gilbert and Ellice groups"; 19 November 1964 - Kuria 1.

Status -- Migrant.

Specimen Records -- None.

8) Heteroscelus incanum — Wandering Tattler

Habitat -- November 1964 - Kuria and Oneaka present on ocean beaches and inland pond areas.

Numbers -- February 1953 to February 1956 - "... well-known on all [Gilbert] islands ..." (Child, 1960); November 1964 - Kuria 15, Oneaka 10.

Status -- Migrant.

Specimen Records - None.

9) Arenaria interpres — Ruddy Turnstone

Habitat -- November 1964 - present on sandy beaches of Kuria and Oneaka.

Numbers -- February 1953 to February 1956 - "... is the commonest of the Arctic visitors [to the Gilbert Islands] ... usually being seen in groups of 10 to 100 or more ..." (Child, 1960); November 1964 - Kuria 40, Oneaka 30.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - two (Table 34). Although Ruddy Turnstone have previously been observed at Kuria Atoll, these two are the first specimens to be collected.

10) Erolia acuminata — Sharp-tailed Sandpiper

Habitat -- 18 November 1964 - Oneaka around inland pond areas.

Numbers -- 18 November 1964 - Oneaka 6 observed, 4 of which were collected, Kuria none.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - four (Table 34). This collection is a new species and specimen record for Kuria Atoll.

11) Sterna sumatrana — Black-naped Tern

Habitat -- November 1964 - sandbar at southern tip of Oneaka, ocean beaches of Kuria.

Numbers -- November 1964 - Kuria 5 observed, Oneaka 6.

Status -- Resident breeder? November 1964 - breeding not observed, but one of two birds collected was an immature suggesting that this species may breed on Kuria Atoll.

Specimen Records -- Other - none, POBSP - two (Table 34). This collection represents a new species and specimen record for Kuria Atoll.

12) Sterna fuscata Sooty Tern

Habitat -- November 1964 - Kuria flying over south portion at dusk (17th), flying north over west beach at 0930 (18th).

Numbers -- Date unknown - "... small colony ... at ... Oneke (Kuria)." (Child, 1960). November 1964 - Kuria 3 flying over late in the afternoon.

Status -- Resident breeder. August (at least before 1949) - "... terns arrive and lay eggs only in August ..." (Richardson and Fisher, 1950, also Ashmole, 1963). Date unknown - Child (1960) implies breeding at Kuria; November 1964 - no breeding observed.

Specimen Records -- None.

13) Thalasseus bergii Crested Tern

Habitat -- February 1953 to February 1956 - presence on sand or gravel bars implied (Child, 1960); November 1964 - Kuria and Oneaka on sandbars and exposed reef rocks.

Numbers -- February 1953 to February 1956 - presence in small numbers implied (Child, 1960); November 1964 - Kuria 5-10, Oneaka 22.

Status -- Resident breeder. February 1953 to February 1956 - breeding implied (Child, 1960); November 1964 - no breeding activity observed, but both adults and flying immatures were present, suggesting that this species nests on Kuria Atoll.

Specimen Records - None.

14) Anous stolidus Brown Noddy

Habitat -- November 1964 - roosting and nesting in frond bases of Cocos trees on both Kuria and Oneaka.

Numbers -- February 1953 to February 1956 - presence ("... fairly common on all islands of the Colony.") implied (Child, 1960); November 1964 - Kuria Island 300-400, Oneaka 400.

Status -- Resident breeder. November 1964 - many adults and young seen on nests at bases of palm fronds on both Kuria and Oneaka Islands; 5 out of 8 adults collected possessed brood patches. This is a new breeding record for Kuria Atoll.

Specimen Records -- Other - none, POBSP - eight (Table 34). This collection represents a new specimen record for Kuria Atoll.

15) Anous tenuirostris — Black Noddy

Habitat -- November 1964 - Kuria and Oneaka roosting and nesting in Cocos and Pisonia trees, more prominent in uninhabited areas but present in villages.

Numbers -- February 1953 to February 1956 - presence in large numbers implied (Child, 1960); November 1964 - Kuria 700+, Oneaka 500+.

Status -- Resident breeder. November 1964 - few active nests seen on both Kuria and Oneaka; 5 of 9 adults collected possessed brood patches. This is a new breeding record for the atoll.

Specimen Records -- Other - none, POBSP - nine (Table 34). This collection represents a new specimen record for Kuria Atoll.

16) Gygis alba — White Tern

Habitat -- November 1964 - Kuria and Oneaka flying over islands, roosting and nesting in Cocos, especially on the tops of the broken off trees.

Numbers -- February 1953 to February 1956 - presence ("... fairly common on all islands ...") indicated (Child, 1960); November 1964-Kuria 300+, Oneaka 200+.

Status -- Resident breeder. November 1964 - many nests observed on Kuria and Oneaka; all five adults collected had brood patches. This is a new breeding record for the atoll.

Specimen Records -- Other - none, POBSP - five (Table 34). These Gygis alba represent a new specimen record for Kuria Atoll.

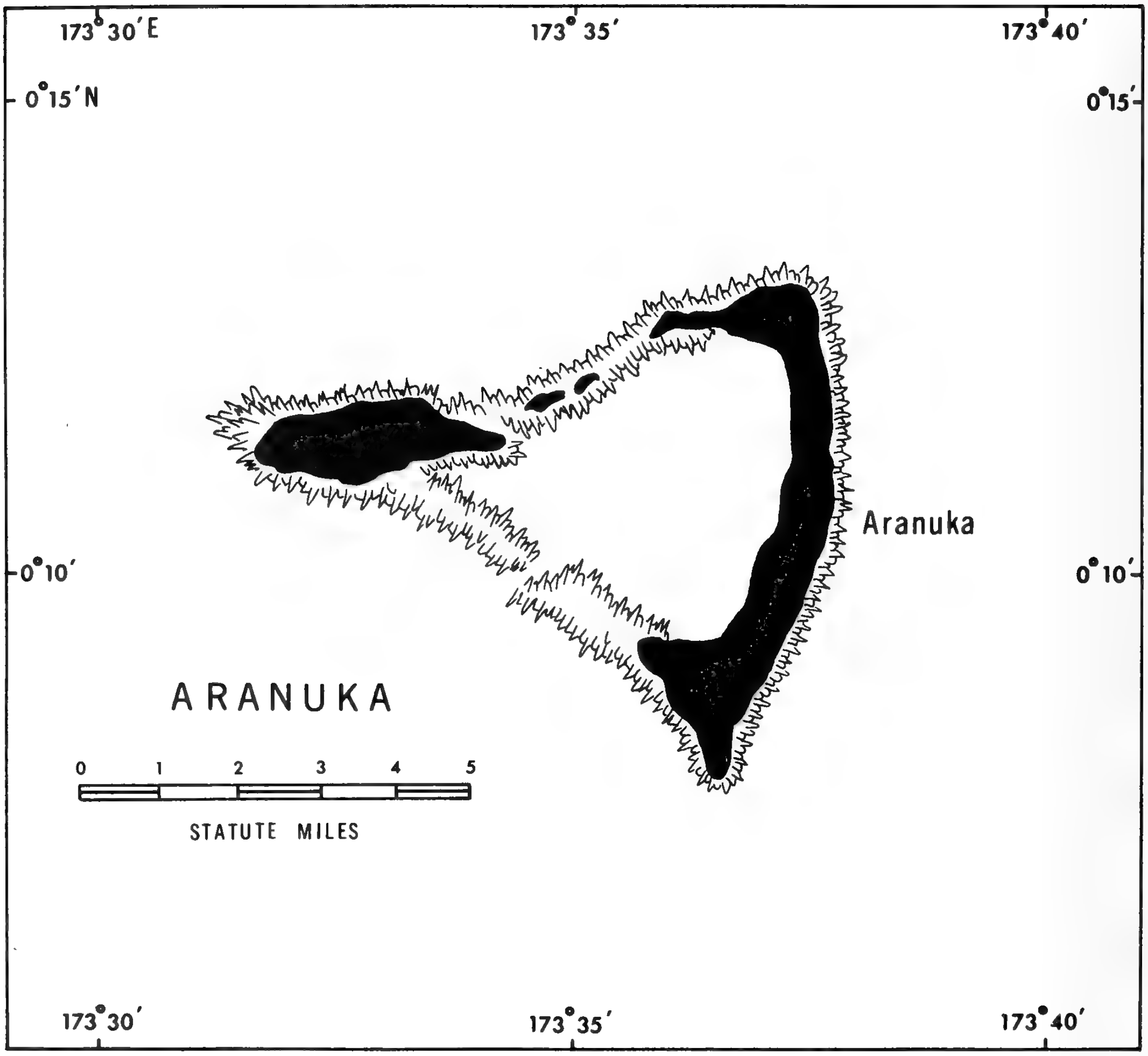
17) Ducula oceanica — Micronesian Pigeon

Habitat -- November 1964 - Kuria observed flying through and roosting in Cocos groves.

Numbers -- November 1964 - Kuria 2 of 4 seen were collected, Oneaka none observed.

Status -- Resident breeder? No breeding activity observed, but natives reported that this species nests on the island.

Specimen Records -- Other - none. POBSP - two (Table 34). This is a new species and specimen record for Kuria Atoll.


173°30′E
173°35′
173°40′
0°15′N
0°15′
Aranuka
0°10′
0°10′
ARANUKA
0 1 2 3 4 5
STATUTE MILES
173°30′
173°35′
173°40′

ARANUKA ATOLL

Location: 00°11' N x 173°36' E.

Shape and Size: Triangular-shaped, east side - 6 miles, northwest side - 7 miles, southwest side - 7 miles; Number of islands - 4 (2 main ones); Total land area - 5.97 square miles; Total lagoon area - 7.5 square miles (H.O. Chart 0122; Mason *in* Freeman, 1951).

Soil: Beach (ocean side) - rocky with some sandy area; Beach (lagoon side) - mostly sandy, extensive mud flat on northwest side of Aranuka Island at low tide; Inland - organic material mixed with sand over coral fragments; no inland ponds.

Vegetation: Primary species - *Cocos*; others include *Pisonia*, *Pandanus*, and *Rhizophora*.

Climate: Moderately dry, rainfall averages 48.37 inches yearly; Air temperature averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 223 (Catala, 1957).

Scientific Visits: Peter Child (1960) - February 1953 to February 1956 various dates; POBSP - 19 November 1964.

Avifauna: Fourteen bird species are presently known from Aranuka Atoll. These include 6 seabirds, 5 shorebirds, 1 heron, 1 pigeon, and 1 domesticated fowl. Only one of these species is known to breed on the atoll, 8 others are possible breeders, and 5 are migrants.

Fourteen species are listed in the following checklist, which was derived from: (1) POBSP, 1964; (2) Child, 1960. These sources are referred to in the checklist by their corresponding numbers. The three species marked by a single asterisk are new species records for Aranuka Atoll; the single species marked by double asterisks is a new atoll breeding record.

Aranuka Atoll Avifauna Checklist

	Species	Status	Source
1)	Egretta sacra	Resident breeder ?	1, 2
2)	Gallus gallus	Introduced breeder ?	1, 2
3)	Pluvialis dominica	Migrant	1, 2
4)	Numenius tahitiensis	Migrant	1, 2
5)	Limosa lapponica	Migrant	1, 2
6)	Heteroscelus incanum	Migrant	1, 2
7)	Arenaria interpres	Migrant	1, 2
8)	Sterna sumatrana*	Resident breeder ?	1
9)	Sterna fuscata*	Resident breeder ?	1
10)	Thalasseus bergii	Resident breeder ?	1, 2
11)	Anous stolidus	Resident breeder**	1, 2
12)	Anous tenuirostris	Resident breeder ?	1, 2
13)	Gygis alba	Resident breeder ?	1, 2
14)	Ducula oceanica*	Resident breeder ?	1

POBSP personnel have collected 30 specimens of 10 species (Table 35). Of these 10 species, 2 are specimen records of species not previously known from Aranuka Atoll; the other 8 represent the first specimen confirmation of species previously known only from sight records. No other specimens are known from the atoll.

Table 35. Bird specimens collected by POBSP from Aranuka Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Pluvialis dominica	USMN 494727	♂	-	Aranuka I	11-19-64	Skin	Huber
" "	" 494728	♀	-	"	"	"	"
Numenius tahitiensis	" 494829	♀	-	"	"	"	Amerson
Heteroscelus incanum	" 494909	♂	-	"	"	"	Huber
" "	" 494910	♂	-	"	"	"	Amerson
" "	" 494911	♂	-	"	"	"	"
Arenaria interpres	" 494790	?	-	"	"	"	"
" "	" 494791	♂	-	"	"	"	"
" "	" 494792	?	-	"	"	"	Huber
" "	" 494793	♀	-	"	"	"	"
Sterna sumatrana	" 494609	♀	-	"	"	"	Amerson
Thalasseus bergii	" 494738	♂	-	lagoon	"	"	Huber
" "	" 494739	♂	-	"	"	"	Amerson
" "	" 494740	♀	-	"	"	"	Huber
Anous stolidus	" 494684	♀	-	Aranuka I	"	"	Amerson
" "	" 494685	♀	-	"	"	"	"
" "	" 494686	♀	-	"	"	"	"
" "	" 494687	♀?	-	"	"	"	"
" "	" 494688	♀	-	"	"	"	Huber
" "	" 494689	♂	-	"	"	"	"
" "	" 494690	♂	-	"	"	"	"
Anous tenuirostris	" 494583	♀	-	"	"	"	Amerson
Gygis alba	" 494648	♂	-	"	"	"	Huber
" "	" 494649	♀	-	"	"	"	"
" "	" 494650	-	-	"	"	"	"
" "	" 494651	♂	-	"	"	"	Amerson
" "	" 494652	-	-	"	"	"	"
" "	" 494653	♀	-	"	"	"	"
Ducula oceanica	" 494817	♂	-	"	"	"	"
" "	" 494818	♀	-	"	"	"	"

Species Accounts

1) <u>Egretta sacra</u> Reef Heron

Habitat -- November 1964 - Aranuka Island present on mud flats at northwest end of island.

Numbers -- February 1953 to February 1956 - "... a familiar sight on all islands of the Gilbert [Islands] ..." (Child, 1960); November 1964 - Aranuka 10.

Status -- Resident breeder? No breeding activity observed, however, this species probably breeds on Aranuka Atoll.

Specimen Records -- None.

2) <u>Gallus gallus</u> Domestic Chicken

Habitat -- November 1964 - Aranuka Island in and around the main village, also scattered throughout the island.

Numbers -- February 1953 to February 1956 - presence implied (Child, 1960); November 1964 - Aranuka Island estimate not made but chickens were commonly observed.

Status -- Introduced breeder? No breeding observed, but this species probably nests on the island.

Specimen Records -- None.

3) <u>Pluvialis dominica</u> Golden Plover

Habitat -- November 1964 - Aranuka Island present on ocean and lagoon beaches, on mud flats, and in open grassy areas around the main village.

Numbers -- February 1953 to February 1956 - presence implied (Child, 1960); November 1964 - Aranuka Island 100 estimated.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - two (Table 35). Another specimen (field #30423), 106 grams, Aranuka Island, 19 November 1964, collector Huber, lost in transit. This collection represents a new specimen record for Aranuka Atoll.

4) <u>Numenius tahitiensis</u> Bristle-thighed Curlew

Habitat -- November 1964 - Aranuka Island present on mud flats.

Numbers -- February 1953 to February 1956 - presence implied (Child, 1960); November 1964 - Aranuka Island 4.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - one (Table 35). This is the first Numenius tahitiensis to be collected from Aranuka Atoll.

5) Limosa lapponica — Bar-tailed Godwit

Habitat -- November 1964 - Aranuka Island on mud flats.

Numbers -- February 1953 to February 1956 - presence possible (Child, 1960); November 1964 - Aranuka Island 8.

Status -- Migrant.

Specimen Records -- None.

6) Heteroscelus incanum — Wandering Tattler

Habitat -- November 1964 - Aranuka Island present along lagoon beach and on mud flats.

Numbers -- February 1953 to February 1956 - presence implied (Child, 1960); November 1964 - Aranuka Island 10.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - three (Table 35). These are the first Wandering Tattlers to be collected from Aranuka Atoll.

7) Arenaria interpres — Ruddy Turnstone

Habitat -- November 1964 - Aranuka Island on ocean and lagoon beaches, and on mud flats.

Numbers -- February 1953 to February 1956 - presence implied (Child, 1960); November 1964 - Aranuka Island 100 estimated.

Status -- Migrant.

Specimen Records -- Other - none; POBSP - four (Table 35). These are the first specimens of Ruddy Turnstones to be collected from Aranuka Atoll.

8) Sterna sumatrana — Black-naped Tern

Habitat -- November 1964 - roosting on poles and feeding in lagoon.

Numbers -- November 1964 - 4 over lagoon, none observed on Aranuka Island. [Note: Morris (1963) observed a Black-naped Tern flying seaward at about 30 feet, three miles north of Aranuka Atoll on 15 July 1963.]

Status -- Resident breeder? November 1964 - breeding not observed, however, this species probably nests on the atoll since the one adult collected had brood patches present suggesting an active nest nearby.

Specimen Records -- Other - none; POBSP - one (Table 35). This represents a new species and specimen record for Aranuka Atoll.

9) Sterna fuscata Sooty Tern

Habitat -- November 1964 - observed in company with a feeding flock of Crested Terns inside of the lagoon near boat passageway through reef.

Numbers -- November 1964 - 2.

Status -- Resident breeder? No breeding activity observed on Aranuka Island.

Specimen Records -- None. This is a new species sight record for Aranuka Atoll.

10) Thalasseus bergii Crested Tern

Habitat -- November 1964 - flying over, feeding in, and roosting on, exposed reef of the lagoon.

Numbers -- February 1953 to February 1956 - presence in small numbers implied (Child, 1960); November 1964 - 25+ over lagoon.

Status -- Resident breeder? No breeding activity observed on Aranuka Island; however, this species could have been nesting on the northern islets of the atoll which were not visited. The three collected adults had no brood patches.

Specimen Records -- Other - none; POBSP - three (Table 35). These represent a new specimen record for Aranuka Atoll.

11) Anous stolidus Brown Noddy

Habitat -- November 1964 - Aranuka Island, present over most of island, roosting and nesting at frond bases of Cocos trees.

Numbers -- February 1953 to February 1956 - presence implied (Child, 1960); November 1964 - Aranuka Island 400+ estimated.

Status -- Resident breeder. November 1964 - Aranuka Island, nests

with chicks observed in _Cocos_ trees. Five of 7 adults collected had brood patches present. This is a new breeding record for the atoll.

Specimen Records -- Other - none ; POBSP - seven (Table 35). These are the first _Anous stolidus_ specimens to be collected from Aranuka Atoll.

12) _Anous tenuirostris_ Black Noddy

Habitat -- November 1964 - Aranuka Island few flying over and roosting in _Cocos_ trees.

Numbers -- February 1953 to February 1956 - presence implied (Child, 1960); November 1964 - Aranuka Island few seen.

Status -- Resident breeder? Aranuka Island no breeding activity observed but this species could (and probably does) nest on the atoll. The collected specimen had feathered brood patches.

Specimen Records - Other - none ; POBSP - one (Table 35). This is the first Black Noddy to be collected from Aranuka Atoll.

13) _Gygis alba_ White Tern

Habitat -- November 1964 - Aranuka Island present throughout island, roosts in _Cocos_ trees.

Numbers -- February 1953 to February 1956 - presence implied (Child, 1960); November 1964 - Aranuka Island 100's present. [Note: Morris (1963) observed White Terns three miles north of Aranuka Atoll on 15 July 1963.]

Status -- Resident breeder? Aranuka Island - no nests observed, however, 5 of 7 adults collected had brood patches, suggesting they were nesting on the atoll.

Specimen Records -- Other - none ; POBSP - six (Table 35). These are the first White Tern specimens to be collected from Aranuka Atoll.

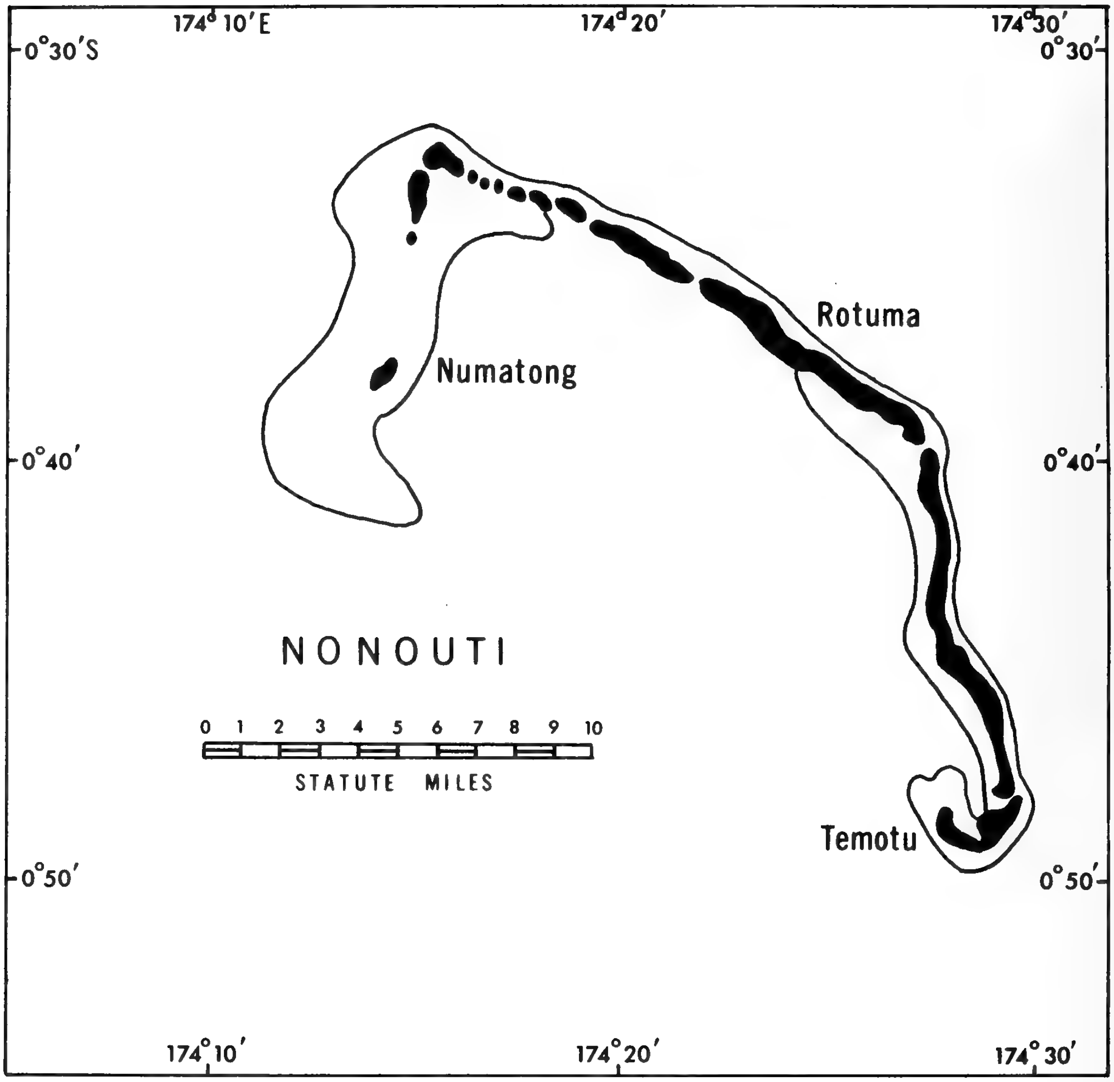
14) _Ducula oceanica_ Micronesian Pigeon

Habitat -- November 1964 - Aranuka Island roosting in _Cocos_ trees and flying about the north end of the island, none seen on the south end of the island.

Numbers -- November 1964 - Aranuka Island 8 seen, of which 2 were collected.

Status -- Resident breeder? Aranuka Island no breeding activity observed, however natives reported this species does nest on the atoll.

Specimen Records -- Other - none; POBSP - two (Table 35). This collection represents a new species and specimen record for Aranuka Atoll.


174° 10′E
174° 20′
174° 30′
0°30′S
0°30′
Rotuma
Numatong
0°40′
0°40′
NONOUTI
0 1 2 3 4 5 6 7 8 9 10
STATUTE MILES
Temotu
0°50′
0°50′
174° 10′
174° 20′
174° 30′

NONOUTI ATOLL

Location: 00°40' S x 174°21' E.

Shape and Size: An irregular oval; Length - about 25 miles; Width - 10 miles; Number of islands - 12 (almost a continuous land rim on northeast face, very little land on southwest face); Total land area - 9.83 square miles; Total lagoon area - 143.00 square miles (Mason *in* Freeman, 1951).

Soil: No data available.

Vegetation: No species listed (Catala, 1957).

Climate: Moderately dry, rainfall averages 43.18 inches yearly; Air temperature averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 2,549 (Catala, 1957).

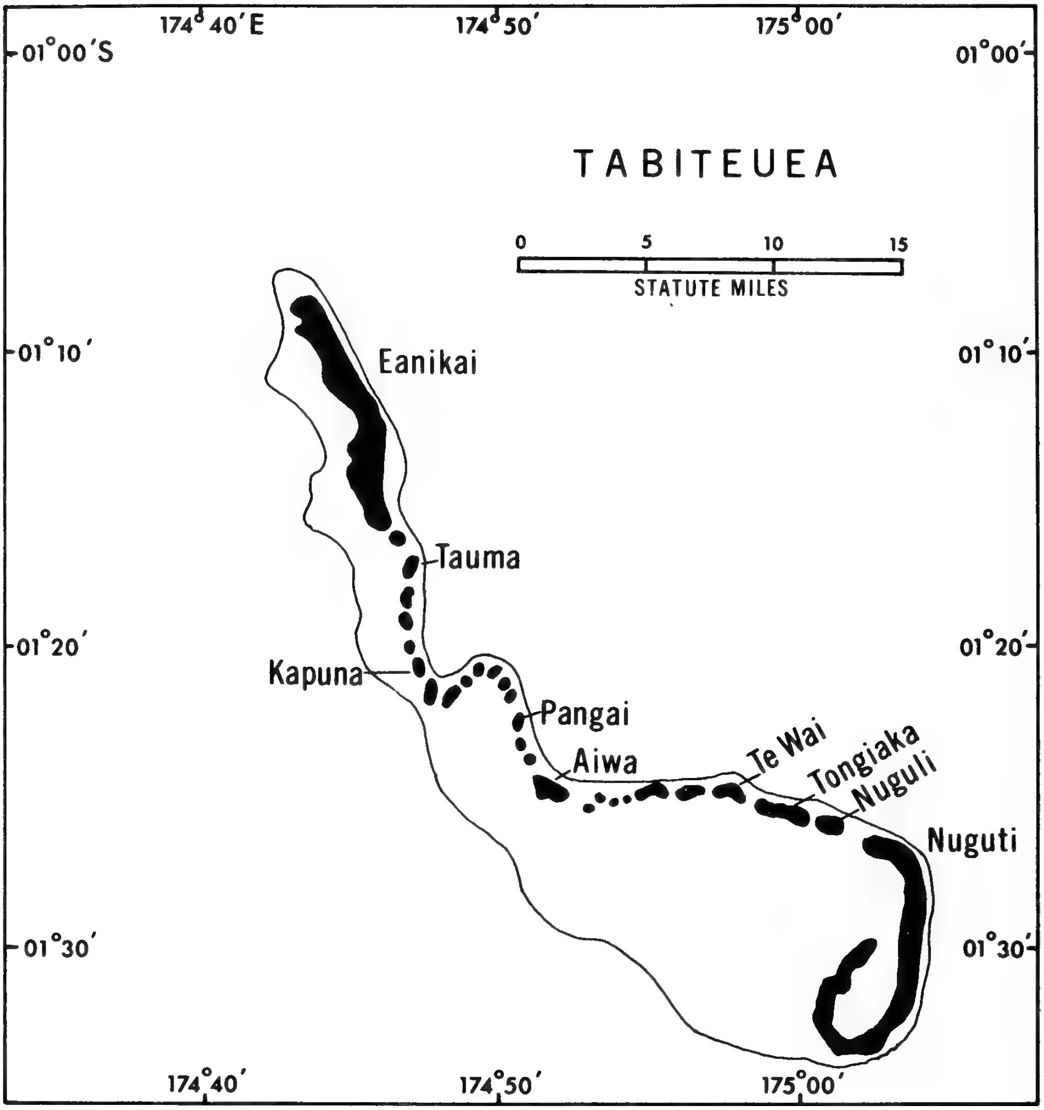
Scientific Visits: Peter Child (1960)- February 1953 to February 1956, various dates; Knell (Morris, 1963) - 7 and 17 August 1963.

Avifauna: Seventeen bird species are known from Nonouti Atoll. These include 9 seabird species, 5 shorebird species, 1 heron, 1 dove, and 1 domestic fowl. Twelve of these species are potential breeders, but only 4 species are known breeders. No museum specimens are known from the atoll.

The following checklist includes those bird species known from Nonouti Atoll. Source material includes: (1) Child, 1960; and (2) Morris, 1963. These sources are referred to in the checklist by their corresponding numbers.

Nonouti Atoll Avifauna Checklist

	Species	Status	Source
1)	Sula leucogaster	Resident breeder ?	1, 2
2)	Fregata ariel	Resident breeder, August	1, 2
3)	Egretta sacra	Resident breeder ?	1, 2
4)	Gallus gallus	Introduced breeder ?	1
5)	Pluvialis dominica	Migrant	1
6)	Numenius tahitiensis	Migrant	1
7)	Limosa lapponica	Migrant	1
8)	Heteroscelus incanum	Migrant	1, 2
9)	Arenaria interpres	Migrant	1, 2
10)	Sterna sumatrana	Resident breeder ?	2
11)	Sterna fuscata	Resident breeder, May (eggs)	1
12)	Sterna lunata	Resident breeder ?	2
13)	Thalasseus bergii	Resident breeder ?	1
14)	Anous stolidus	Resident breeder ?	1, 2
15)	Anous tenuirostris	Resident breeder, August (eggs)	1, 2
16)	Gygis alba	Resident breeder ?	1, 2
17)	Gallicolumba erythroptera (Ground Dove)	Introduced breeder, June (eggs)	1



174°40′E
174°50′
175°00′
01°00′S
01°00′
TABITEUEA
0
5
10
15
STATUTE MILES
01°10′
01°10′
Eanikai
Tauma
01°20′
01°20′
Kapuna
Pangai
Aiwa
Te Wai
Tongiaka
Nuguli
Nuguti
01°30′
01°30′
174°40′
174°50′
175°00′

TABITEUEA ATOLL

Location: 01°20' S x 174°50' E.

Shape and Size: An irregular shape - concave eastern face 30 miles long, convex western face 30 miles long, rounded southern portion 6 miles wide, pointed northern end; Number of islands - 2 main islands plus numerous small islets (land rim only on the eastern and southern faces); Total land area - 19.00 square miles; Total lagoon area - 141.00 square miles (Agassiz, 1903; Mason in Freeman, 1951).

Soil: Beach (ocean) - mostly conglomerate beach rock; Beach (lagoon) - mostly fine coral sand (Agassiz, 1903).

Vegetation: Mostly Cocos, Pandanus (Agassiz, 1903); four species listed by Catala (1957).

Climate: Moderately dry; rainfall averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 4,239 (Catala, 1957).

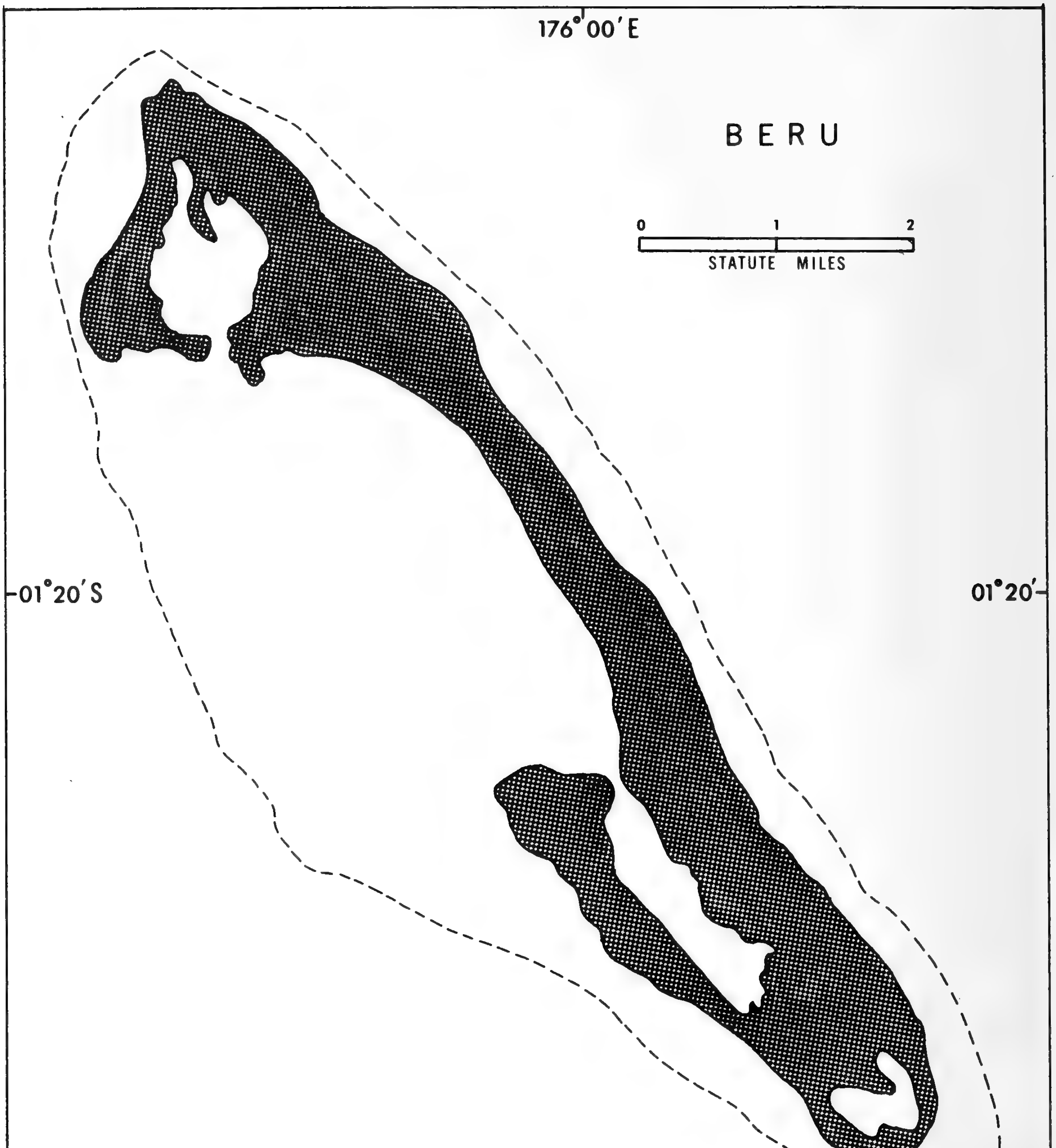
Scientific Visits: "Albatross" Tropical Pacific Expedition - 1900; Peter Child (1960; personal communication, August 1964)- May 1953 to January 1956, various dates.

Avifauna: Sixteen species of birds are known from Tabiteuea Atoll. [Note: Morris (1963) also saw another species which was either a cormorant or a duck.] Of these species, 9 are seabirds, 5 are shorebirds, 1 is a heron, and 1 is a domestic fowl. Potential breeders include 10 of the species, however, only 1 species is known to breed. No museum specimens are known from the atoll.

The known species from Tabiteuea Atoll are included in the following checklist. Source material includes: (1) Child, 1960; and (2) Morris, 1963. These species are referred to in the checklist by their corresponding numbers.

Tabiteuea Atoll Avifauna Checklist

	Species	Status	Source
1)	Nesofregetta albigularis	Resident breeder ?	2
2)	Sula sula	Resident breeder ?	1
3)	Sula leucogaster	Resident breeder ?	2
4)	Fregata ariel	Resident breeder ?	2
5)	Egretta sacra	Resident breeder ?	1, 2
6)	Anatidae sp. (?)	Accidental	2
7)	Gallus gallus	Introduced breeder ?	1
8)	Pluvialis dominica	Migrant	1
9)	Numenius tahitiensis or phaeopus	Migrant	1, 2
10)	Limosa lapponica	Migrant	1
11)	Heteroscelus incanum	Migrant	1
12)	Arenaria interpres	Migrant	1
13)	Sterna lunata	Resident breeder ?	2
14)	Thalasseus bergii	Resident breeder ?	1
15)	Anous stolidus	Resident breeder ?	1, 2
16)	Anous tenuirostris	Resident breeder, February to October	1, 2
17)	Gygis alba	Resident breeder ?	1, 2


176°00′E
BERU
0
1
2
STATUTE MILES
01°20′S
01°20′
176°00′

BERU ISLAND

Location: 01°20' S x 176°00' E.

Shape and Size: Oval island; Length - 10 miles; Width - 4 miles; Total land area - 8.15 square miles; Total lagoon area - 15.00 square miles (H.O. chart 0119; Mason *in* Freeman, 1951).

Soil: No data available.

Vegetation: Probably mainly *Cocos*; six plant species listed by Catala (1957).

Climate: Moderately dry; rainfall averages 45.29 inches yearly; Air temperature averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 2,167 (Catala, 1957).

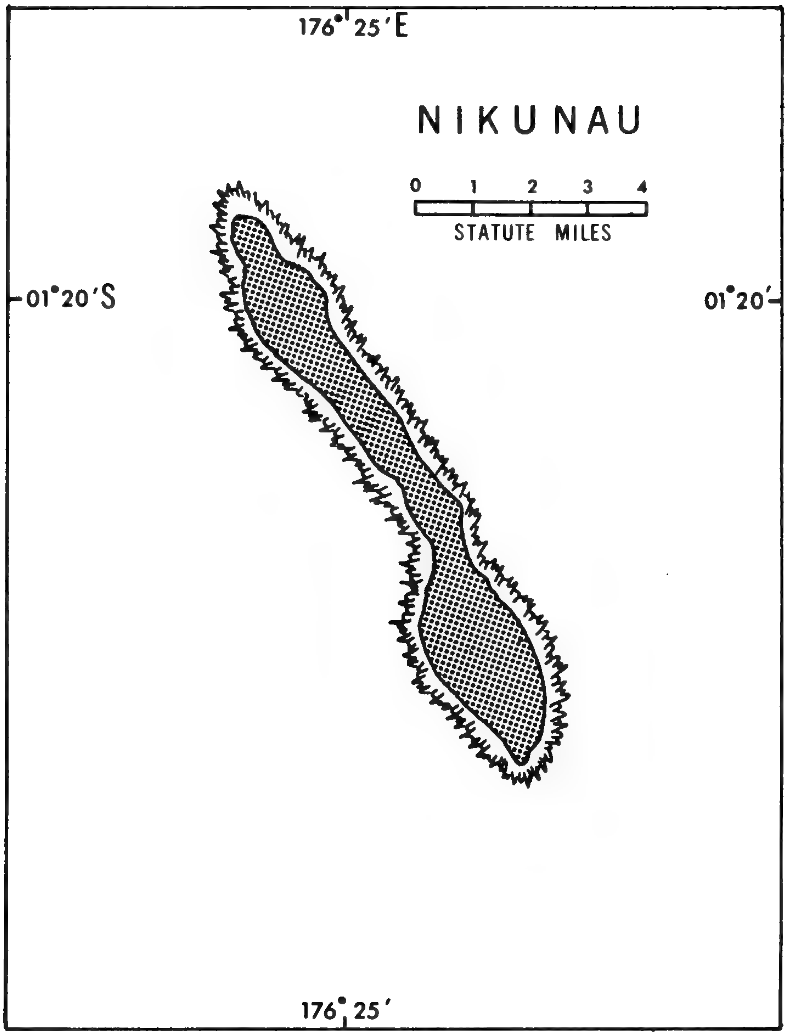
Scientific Visits: Peter Child (1960; personal communication, August 1965) - May 1953 to January 1956, various dates.

Avifauna: Eleven species of birds are known from Beru Island, including 4 seabird species, 5 shorebird species, 1 heron, and 1 domestic fowl. Six of these species are potential breeders, but no breeding birds have been reported from the island. No museum specimens are known from the island.

Child (1960) implied that the bird species included in the following checklist were present on Beru Island.

Beru Island Avifauna Checklist

	Species	Status
1)	*Egretta sacra*	Resident breeder ?
2)	*Gallus gallus*	Introduced breeder ?
3)	*Pluvialis dominica*	Migrant
4)	*Numenius tahitiensis*	Migrant
5)	*Limosa lapponica*	Migrant
6)	*Heteroscelus incanum*	Migrant
7)	*Arenaria interpres*	Migrant
8)	*Thalasseus bergii*	Resident breeder ?
9)	*Anous stolidus*	Resident breeder ?
10)	*Anous tenuirostris*	Resident breeder ?
11)	*Gygis alba*	Resident breeder ?


176° 25′E
NIKUNAU
0 1 2 3 4
STATUTE MILES
01°20′S
01°20′
176° 25′

NIKUNAU ISLAND

Location: 01°23' S x 176°26' E.

Shape and Size: Narrow elongated island, about 9 miles long, 2 miles wide; Total land area - 7.00 square miles; No lagoon (H.O. Chart 0119 ; Mason *in* Freeman, 1951).

Soil: No data available.

Vegetation: Probably mainly *Cocos*; eleven species listed by Catala (1957).

Climate: Moderately dry, rainfall averages 42.10 inches yearly; Air temperature averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 1,913 (Catala, 1957).

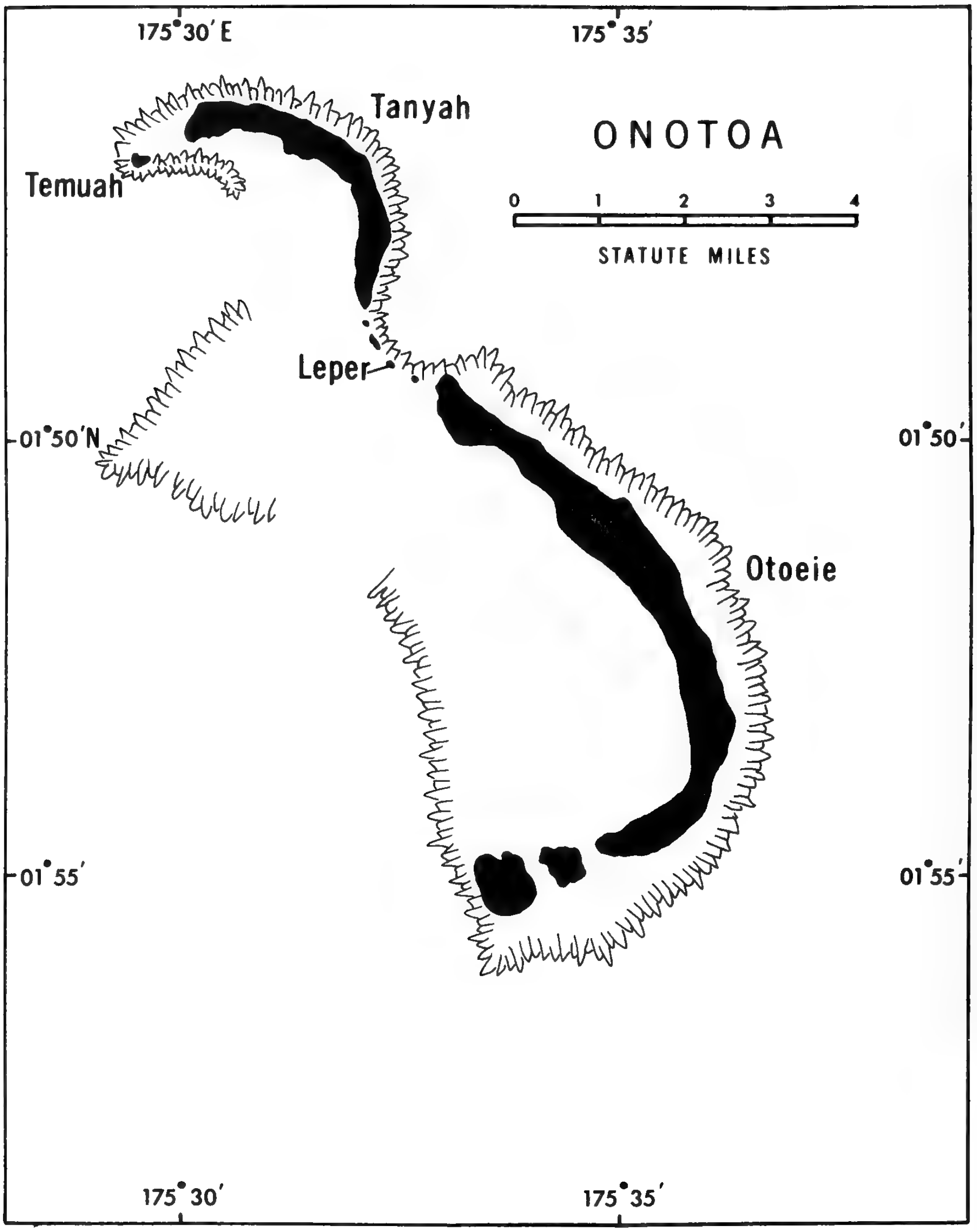
Scientific Visits: Peter Child (1960; personal communications, August 1965)- May 1953 to January 1956, various dates.

Avifauna: Twelve bird species are known from Nikunau Atoll. These include 5 seabird species, 5 shorebird species, 1 heron, and 1 domestic fowl. No breeding birds have been reported from the atoll, however, seven of these species are potential breeders. No museum specimens exist from Nikunau Atoll.

The following checklist of 12 bird species was taken from (1) POBSP band data and(2) Child (1960). Child implied that the species included in the following checklist were present on Nikunau Atoll. The species marked with an asterisk is a new island record.

Nikunau Island Avifauna Checklist

	Species	Status	Source
1)	*Sula dactylatra**	Resident breeder ?	1
2)	*Egretta sacra*	Resident breeder ?	2
3)	*Gallus gallus*	Introduced breeder ?	2
4)	*Pluvialis dominica*	Migrant	2
5)	*Numenius tahitiensis*	Migrant	2
6)	*Limosa lapponica*	Migrant	2
7)	*Heteroscelus incanum*	Migrant	2
8)	*Arenaria interpres*	Migrant	2
9)	*Thalasseus bergii*	Resident breeder ?	2
10)	*Anous stolidus*	Resident breeder ?	2
11)	*Anous tenuirostris*	Resident breeder ?	2
12)	*Gygis alba*	Resident breeder ?	2



175°30′ E
175° 35′
Tanyah
ONOTOA
Temuah
0
1
2
3
4
STATUTE MILES
Leper
01°50′N
01°50′
Otoeie
01°55′
01°55′
175° 30′
175°35′

ONOTOA ATOLL

Location: 01°52' S x 175°34' E.

Shape and Size: Irregular-shaped;Tip to tip (north-south) - 11 miles; Width - 5 miles; Number of islands - 30, 4 small (all on east side); Total land area - 5.21 square miles; Lagoon area - 21.00 square miles (Mason in Freeman, 1951; Cloud, 1952; Moul, 1957).

Soil: Land surface mostly unconsolidated sand (lagoonward) and gravel (seaward); Humus layer up to 10 inches; Beaches - sandy, rocky, and gravelly (Cloud, 1952).

Vegetation: Primary species-*Cocos nucifera*; Total flowering plant species - 60 (Moul, 1957).

Climate: Relatively dry, rainfall averages 45.83 inches yearly (some drought years); Air temperature averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 1,694 (Catala, 1957).

Scientific Visits: "Albatross" Tropical Pacific Expedition - 1899; Pacific Science Board field team - August 1951; Peter Child (1960) - February 1953 to February 1956, various dates.

Avifauna: Nineteen species of birds are presently known from Onotoa Atoll. These include 10 seabird species, 6 shorebird species, 1 heron, 1 cuckoo, and 1 domestic fowl. Twelve species are potential breeders; however, only 9 species are known to breed.

The 19 known species of birds from Onotoa Atoll are included in the following checklist. Source material includes (1) Moul, 1954; (2)Child,1960. These sources are indicated in the checklist by their corresponding numbers.

Onotoa Atoll Avifauna Checklist

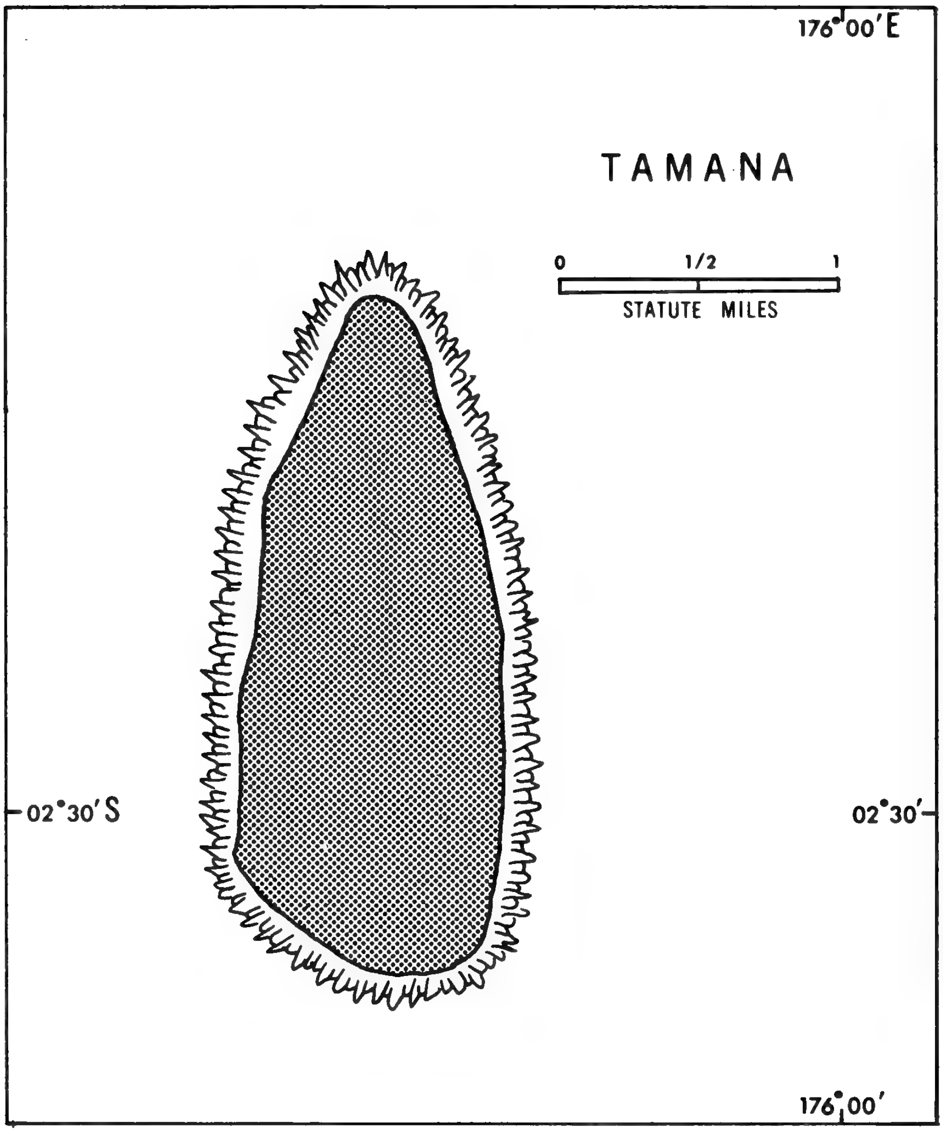
	Species	Status	Source
1)	*Phaethon rubricauda*	Resident breeder ?	1
2)	*Sula sula*	Resident breeder August (young)	2
3)	*Fregata minor*	Resident breeder ?	2
4)	*Fregata ariel*	Resident breeder (date?)	1, 2
5)	*Egretta sacra*	Resident breeder (summer)	1, 2
6)	*Gallus gallus*	Introduced breeder	1, 2
7)	*Pluvialis dominica*	Migrant	1, 2
8)	*Numenius phaeopus*	Migrant	1

Species	Status	Source
9) Numenius tahitiensis	Migrant	2
10) Limosa lapponica	Migrant	2
11) Heteroscelus incanum	Migrant	1,2
12) Arenaria interpres	Migrant	1,2
13) Sterna sumatrana	Resident breeder, January to September	1,2
14) Sterna fuscata	Resident breeder ?	1
15) Thalasseus bergii	Resident breeder, July August (immatures)	1,2
16) Anous stolidus	Resident breeder, summer	1,2
17) Anous tenuirostris	Resident breeder, summer	1,2
18) Gygis alba	Resident breeder, summer (young)	1,2
19) Urodynamis taitensis	Migrant	1

Ten bird specimens have been collected from Onotoa Atoll. These skins were collected and prepared by E.T. Moul and are all deposited in the U.S. National Museum, Washington, D.C. These specimens include eight species and are shown in Table 36.

Table 36. Bird specimens collected from Onotoa Atoll.

Species	Museum	Sex	Age	Location	Date	Status	Collector
Egretta sacra	USNM 437212	♂		Onotoa A.	08-12-51	Skin	Moul
" "	" 437213	-		"	07-13-51	"	"
Pluvialis dominica	" 437220	♂		"	08-19-51	"	"
Heteroscelus incanum	" 437221	-	Imm	"	"	"	"
Arenaria interpres	" 437219	-		"	"	"	"
Sterna sumatrana	" 437217	♂	Imm	"	08-16-51	"	"
Thalasseus bergii	" 437214	♂		"	08-19-51	"	"
Anous stolidus	" 437215	-	Imm	"	07-14-51	"	"
Gygis alba	" 437216	-		"	07-05-51	"	"
" "	" 437218	-		"	07-16-51	"	"


176°00′E
TAMANA
0
1/2
1
STATUTE MILES
02°30′S
02°30′
176°00′

TAMANA ISLAND

Location: 02°29' S x 175°59' E.

Shape and Size: An oval island, about 2-1/2 miles long, 1 mile wide; Total land area - 2.00 square miles; No lagoon (H.O. Chart 0119; Mason in Freeman, 1951).

Soil: No data available.

Vegetation: Presence of four plant species implied (Catala, 1957).

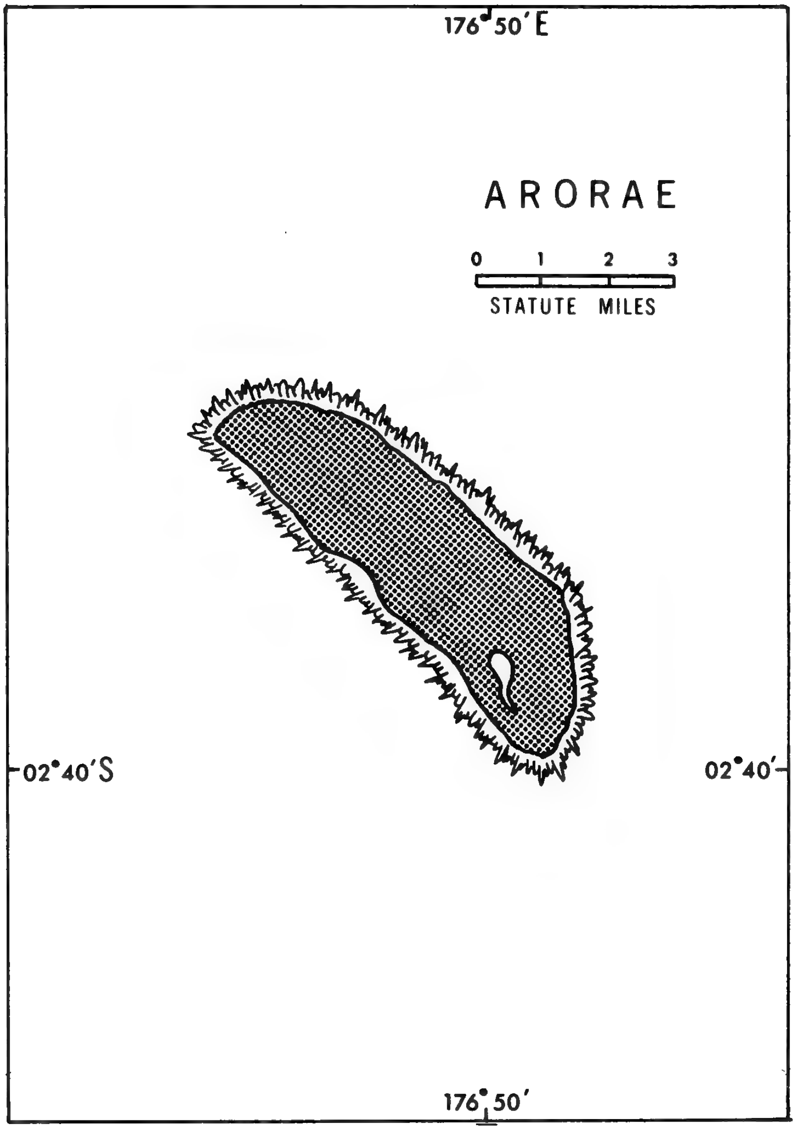
Climate: Moderately dry - rainfall averages 50.39 inches yearly; Air temperature - averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 1,092 (Catala, 1957).

Scientific Visits: None known. [Note: Child (1960) did not visit Tamana Island (Child, personal communication, August 1965)].

Avifauna: One bird species, a seabird, is known from Tamana Island. This species, *Fregata ariel*, was recorded from POBSP band return data. This is a new species record for Tamana Island.

Species likely to be found include: *Egretta sacra*, *Gallus gallus*, *Pluvialis dominica*, *Numenius tahitiensis*, *Heteroscelus incanum*, *Arenaria interpres*, *Sterna sumatrana*, *Thalasseus bergii*, *Anous stolidus*, *Anous tenuirostris*, *Gygis alba*, *Ducula oceanica*, and *Urodynamis taitensis*.


176°50′E
ARORAE
0 1 2 3
STATUTE MILES
02°40′S
02°40′
176°50′

ARORAE ISLAND

Location: 02°38' x 176°49'E.

Shape and Size: An oval island about 6 miles long, 1/2 mile wide; Total land area - 5.00 square miles; No lagoon, but a small brackish pond exists in the southern part of the island (Agassiz, 1903; Mason in Freeman, 1951).

Soil: Beaches - steep rock shingle, conglomerate beach rock and sand (Agassiz, 1903).

Vegetation: Probably mainly Cocos; five plant species listed by Catala (1957).

Climate: Moderately dry - rainfall averages 52.30 inches yearly; Air temperature - averages 83-84° F.; Wind - prevailing from east (Sachet, 1957).

Human Population: 1950 - 1,576 (Catala, 1957).

Scientific Visits: "Albatross" Tropical Pacific Expedition - 1900; Peter Child (1960; personal communication, August 1965) - May 1953 to January 1956, various dates.

Avifauna: Twelve bird species are known from Arorae Island. These include 5 seabird species, 5 shorebird species, 1 heron, and 1 domestic fowl. Seven of these species are potential breeders, however, no breeding birds are known from the island. No museum specimens have been collected from the island.

The 12 species in the following checklist were taken from (1) POBSP band returns, and (2) Child (1960). Child implied that bird species were present on Arorae Island. The one species marked by an asterisk is a new record for the island.

Arorae Island Avifauna Checklist

Species	Status	Source
1) *Fregata minor*	Resident breeder ?	1, 2
2) *Fregata ariel**	Resident breeder ?	1
3) *Egretta sacra*	Resident breeder ?	2
4) *Gallus gallus*	Introduced breeder ?	2
5) *Pluvialis dominica*	Migrant	2
6) *Numenius tahitiensis*	Migrant	2
7) *Limosa lapponica*	Migrant	2
8) *Heteroscelus incanum*	Migrant	2
9) *Arenaria interpres*	Migrant	2
10) *Thalasseus bergii*	Resident breeder ?	2
11) *Anous stolidus*	Resident breeder ?	2
12) *Anous tenuirostris*	Resident breeder ?	2

AVIFAUNAL DISTRIBUTION

AVIFAUNAL DISTRIBUTION

GENERAL

Seventy-nine species of birds have thus far been recorded from the 50 atolls which make up the Marshall and Gilbert Islands and from the ocean surrounding them. Of these 79 species, 37 are seabirds (Table 37) and 42 are land and fresh-water birds (Table 38).

Seventy bird species have been recorded from the Marshall Islands; 43 species have been recorded from the Gilberts. Thirty-five species are found in both island groups; 35 are known solely from the Marshalls; 9 are known solely from the Gilberts.

SEABIRDS

Thirty-one seabird species have been recorded from the Marshall Islands; 25 have been recorded from the Gilberts (Table 37). Nineteen seabird species are recorded from both island groups; 12 are known solely from the Marshalls; 6 are known solely from the Gilberts.

Seven seabird species are resident breeders on both island groups; in addition, three species that are resident breeders in the Marshall Islands are possible breeders in the Gilbert Islands. Seven others (including two in question) are resident breeders solely on the Marshall Islands, while only two (including one in question) are resident breeders solely on the Gilbert Islands.

The resident, including probable and possible, breeding seabirds in the Marshall and Gilbert Islands all regularly occur at sea within their respective areas. Some are more common than others, mainly due to species feeding habitat preference (also interaction of surface water zonation and abundance of food). The three major feeding habitat categories, for Marshall-Gilbert seabirds, are coastal (beaches, reefs, lagoons), offshore (near islands or atolls), and pelagic. Some species may overlap or their range may vary at different times during the year. Table 39 shows which Marshall-Gilbert breeding species generally occur in the three feeding habitats.

Seven seabird species (Table 37) are known to migrate annually through the Marshall-Gilbert area from breeding grounds elsewhere in the Pacific. These migrant species are usually entirely pelagic and pass through the area quickly. Occasionally, due to storms, injuries, or sickness, individuals may occur on the islands; these are then considered accidental to the island avifauna.

One seabird species (Table 37) is a vagrant in the Marshall-Gilbert area. Such birds are so classified because they are away from their normal migration routes. If these stop on an island, they are also known as accidentals to the island avifauna.

Table 37. Seabird occurrence in the Marshall and Gilbert Islands.

	Species	Marshall Islands	Marshall At Sea	Gilbert Islands	Gilbert At Sea
1)	Black-footed Albatross	-	Visitor	-	-
2)	Laysan Albatross	Accidental	&	-	-
3)	Phoenix Petrel	-	-	-	Visitor
4)	Kermadec Petrel	-	Migrant	-	#
5)	White-necked Petrel	Accidental	#	-	#
6)	Black-winged Petrel	-	#	-	Migrant
7)	Bulwer's Petrel	Resident breeder ?	Uncommon	-	Visitor
8)	Pale-footed Shearwater	-	Migrant	-	+
9)	Wedge-tailed Shearwater	Resident breeder	Uncommon	-	-
10)	Sooty Shearwater	Accidental	Migrant	-	Migrant
11)	Slender-billed Shearwater	Accidental	Migrant	-	Migrant
12)	Christmas Shearwater	Resident breeder	Uncommon		Visitor
13)	Little Shearwater	Accidental	-	-	-
14)	Audubon's Shearwater	-	-	-	Visitor
15)	Leach's Storm Petrel	-	Migrant	-	Migrant
16)	White-throated Storm Petrel	-	-	Resident breeder ?	+
17)	Red-billed Tropicbird	-	-	-	Vagrant
18)	Red-tailed Tropicbird	Resident breeder	Common	Resident breeder ?	Uncommon
19)	White-tailed Tropicbird	Resident breeder	Uncommon	-	Visitor
20)	Blue-faced Booby	Resident breeder	Uncommon	Visitor	Visitor
21)	Red-footed Booby	Resident breeder	Common	Resident breeder	+
22)	Brown Booby	Resident breeder	Uncommon	Resident breeder ?	Uncommon
23)	Great Frigatebird	Resident breeder	Uncommon	Resident breeder ?	Uncommon
24)	Lesser Frigatebird	Visitor	&	Resident breeder	Common
25)	Great Skua	-	#	-	Migrant
26)	Jaeger	Accidental	#	-	-
27)	Common Tern	Accidental	*	-	-

Table 37 (cont.). Seabird occurrence in the Marshall and Gilbert Islands.

	Species	Marshall Islands	Marshall At Sea	Gilbert Islands	Gilbert At Sea
28)	Arctic Tern	Accidental	*	-	-
29)	Black-naped Tern	Resident breeder	Rare	Resident breeder	Rare
30)	Gray-backed Tern	Resident breeder ?	+	Visitor	Uncommon
31)	Sooty Tern	Resident breeder	Common	Resident breeder	Uncommon
32)	Brown-winged Tern	Accidental	*	-	-
33)	Crested Tern	Resident breeder	Rare	Resident breeder	Rare
34)	Blue-gray Noddy	Resident breeder	Uncommon	-	-
35)	Brown Noddy	Resident breeder	Common	Resident breeder	Common
36)	Black Noddy	Resident breeder	Common	Resident breeder	Common
37)	White Tern	Resident breeder	Common	Resident breeder	Common

- none recorded.
* none recorded, but probably vagrant in the area.
# none recorded, but probably migrant in the area.
& none recorded, but probably a visitor in the area.
+ none recorded, but probably occurs.

Table 38. Land and fresh-water bird occurrence in the Marshall and Gilbert Islands.

	Species	Marshall Islands	Gilbert Islands
1)	Reef Heron	Resident breeder	Resident breeder
2)	Snow Goose	Accidental	-
3)	Mallard	Accidental	Accidental
4)	Common Teal	Accidental	-
5)	Gadwall	Accidental	-
6)	European Widgeon	Accidental	-
7)	Pintail	Uncommon Migrant	-
8)	Northern Shoveler	Uncommon Migrant	Migrant
9)	Canvasback	Accidental	-
10)	Tufted Duck	Accidental	-
11)	Muscovy Duck	Introduced breeder	-
12)	Duck sp.	Accidental	Accidental
13)	Domestic Chicken	Introduced breeder	Introduced breeder
14)	White-browed Rail	Accidental	-
15)	Golden Plover	Common Migrant	Common Migrant
16)	Black-bellied Plover	Uncommon Migrant	-
17)	Semipalmated Plover	Uncommon Migrant	-
18)	Ring-necked Plover	Uncommon Migrant	-
19)	Mongolian Plover	Uncommon Migrant	-
20)	Plover sp.	Accidental	-
21)	Whimbrel	Common Migrant	Common Migrant
22)	Bristle-thighed Curlew	Common Migrant	Common Migrant
23)	Bar-tailed Godwit	Common Migrant	Common Migrant
24)	Greater Yellowlegs	Accidental	-
25)	Spotted Sandpiper	Accidental	-
26)	Polynesian Tattler	Uncommon Migrant	Uncommon Migrant
27)	Wandering Tattler	Common Migrant	Common Migrant
28)	Ruddy Turnstone	Common Migrant	Common Migrant
29)	Japanese Snipe	Accidental	-
30)	Sanderling	Common Migrant	Uncommon Migrant
31)	Pectoral Sandpiper	Uncommon Migrant	-
32)	Sharp-tailed Sandpiper	Common Migrant	Common Migrant
33)	Buff-breasted Sandpiper	Accidental	-
34)	Stilt sp.	-	Accidental
35)	Ground Dove	-	Introduced breeder
36)	Friendly Ground Dove	-	Introduced, breeder?
37)	Crimson-crowned Fruit Dove	Extinct breeder	-
38)	Micronesian Pigeon	Resident breeder	Resident breeder ?
39)	Parrot sp.	Probably introduced	-
40)	Long-tailed New Zealand Cuckoo	Common Migrant	Common Migrant
41)	House Sparrow	Probably introduced, possible breeder	-
42)	Indian Myna	Introduced breeder	-

Table 39. At-sea feeding habitat classification of seabirds that breed in the Marshall and Gilbert Islands.

Species	Coastal	Offshore	Pelagic
Bulwer's Petrel		x	x
Wedge-tailed Shearwater		x	x
Christmas Shearwater		x	x
White-throated Storm Petrel		x	x
Red-tailed Tropicbird			x
White-tailed Tropicbird			x
Blue-faced Booby		x	x
Red-footed Booby		x	x
Brown Booby		x	
Great Frigatebird		x	x
Lesser Frigatebird		x	x
Black-naped Tern	x		
Gray-backed Tern		x	x
Sooty Tern		x	x
Crested Tern	x		
Blue-gray Noddy	x	x	
Brown Noddy		x	
Black Noddy	x	x	
White Tern		x	x

Three seabird species (Table 37) are visitors to the Marshall-Gilbert area from nearby island groups. Some, which breed in the Marshalls, are visitors to the Gilberts, and vice versa.

DIOMEDEIDAE   Albatrosses

Albatrosses are the largest seabirds found in the Marshall-Gilbert area. In general, they have long, slender wings supporting rather stout bodies, short tails, and large, hooked bills. Two species, both visitors from the North Pacific, occur only in the Marshall Islands, where they are known from a few records. No albatrosses have been recorded below 10° N in the Marshall-Gilbert area.

Diomedia nigripes   Black-footed Albatross

Status -- At-sea visitor in the northern Marshalls.

Marshall-Gilbert Distribution Records -- Breeding: no valid breeding records. Other: Marshalls - offshore Taongi (Fosberg, 1966). At-sea: Marshalls - found occasionally above 10° N.

Pacific Distribution -- Breeds in the Leeward Hawaiians and the Izu Group. Found above 10° N in the entire North Pacific during the nonbreeding season.

Diomedea immutabilis   Laysan Albatross

Status -- Accidental on islands in the northern Marshalls, probably at-sea visitor.

Marshall-Gilbert Distribution Records -- Marshalls - Mejit (10°17' N).

Pacific Distribution -- Breeds in the Leeward Hawaiians. Found at sea normally south to 15° N in the central Pacific during breeding season, north of 35° N during nonbreeding season.

PROCELLARIIDAE   Gadfly Petrels, Shearwaters

Gadfly Petrels are small to medium-sized seabirds, which, superficially, resemble shearwaters but their wings are broader, tails usually longer and wedge-shaped, and bills shorter and heavier. The paired tubular nostrils are very prominent. Five gadfly petrels are known from the Marshall-Gilbert area. One of these species is a probable breeder in the northern Marshalls; one species (and possibly two others) migrate from South Pacific breeding areas through the Marshalls. No gadfly petrels breed in the Gilbert Islands; one species (and possibly two others) annually migrate through the Gilberts from the South Pacific; one species visits the Gilberts from the Marshalls, and another visits from the nearby Phoenix Islands.

Shearwaters are small to medium-sized seabirds, with long narrow

wings, heavy bodies, and short tails. Their long, thin, hooked bills have paired tubular external nostrils. Seven shearwater species are known from the Marshall-Gilbert area. Two of these species breed in the northern Marshall Islands; three others migrate from the extreme South Pacific through the Marshalls to the temperate and arctic regions of the North Pacific during their nonbreeding seasons; an additional species, which also breeds in the far South Pacific but does not migrate through the area, is accidental to the Marshalls. No shearwaters breed in the Gilbert Islands; two species annually migrate through the Gilberts from the South Pacific; one species visits the Gilberts from the Marshalls, while another visits from the nearby Phoenix Islands.

Pterodroma alba — Phoenix Petrel

Status -- At-sea visitor in the Gilbert Islands.

Marshall-Gilbert Distribution Records -- At-sea: Gilberts - Finsch (1880) reported one individual, possibly of this species (Bourne *in* Morris, 1963).

Pacific Distribution -- Breeds on scattered island groups throughout the southern tropical Pacific.

Pterodroma neglecta — Kermadec Petrel

Status -- At-sea migrant through the eastern Marshall Islands; possible at-sea migrant in the Gilberts.

Marshall-Gilbert Distribution Records -- At-sea: Marshalls - one seen between Bikar and Taka October 1964.

Pacific Distribution -- Breeds on many island groups of the southern tropical Pacific; found at sea across the South Pacific, including the subtropical region, ranges into the north-central Pacific during non-breeding season.

Pterodroma externa — White-necked Petrel

Status -- Accidental on islands in the Marshalls; probable at-sea migrant in Marshalls and Gilberts.

Marshall-Gilbert Distribution Records -- Marshalls - Mili. Note: Reported in error as a migrant October-November 1964 by King (1967:112).

Pacific Distribution -- Two races occur: *Pterodroma externa cervicalis* breeds on the Kermadec Islands; *P. e. externa* breeds in the Juan Fernandez Islands. Both forms winter in the central Pacific.

Pterodroma hypoleuca nigripennis — Black-winged Petrel

Status -- At-sea migrant through the Marshall (?) and Gilbert Islands.

Marshall-Gilbert Distribution Records -- At-sea: Gilberts - individuals, possibly of this species, present between Tabiteuea and Nonouti July 1963, and south of Tabiteuea August 1963 (Morris, 1963); one seen between Makin and Maiana and two others between Maiana and Kuria November 1964.

Pacific Distribution -- Breeds in the Kermadec and Three Kings Islands; migrates to the north-central Pacific (up to 25° N latitude) during the nonbreeding season.

Bulweria bulwerii Bulwer's Petrel

Status -- Probably a resident breeder in the extreme northern Marshalls.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - probably breeds at Taongi. At-sea: Marshalls - one observed south of Jaluit at 07° N x 169° E on 2 November 1960 (Bruyns, 1964); common above 11° N during April 1967, one individual observed [listed as Sooty ? Storm Petrel by King (1967:112)] between Makin and Maiana and between Maiana and Kuria November 1964.

Pacific Distribution -- Breeds on the Hawaiian, Marquesas, Phoenix, Bonin, Volcanic, and probably Marshall Islands.

Puffinus carneipes Pale-footed Shearwater

Status -- Uncommon at-sea migrant in the Marshalls.

Marshall-Gilbert Distribution Records -- At-sea: Marshalls - 3 flying south at 07° N x 171° E (at Jaluit) on 2 November 1960 (Bruyns, 1964).

Pacific Distribution -- Breeds on islands in Australia-New Zealand area; migrates north through the western Pacific past Japan into the north Pacific and south through the eastern, central, and south-central Pacific.

Puffinus pacificus Wedge-tailed Shearwater

Status -- Resident breeder in the northern Marshalls.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar, Taka. Other: Marshalls - Eniwetok, Bikini, Rongerik, Rongelap, Jaluit (?). At-sea: Marshalls - 13 near Jaluit 2 November 1960 (Bruyns, 1964); common around Taongi and Bikar during October 1964 and April 1967; between Kwajalein and Jaluit October 1964.

Pacific Distribution -- Breeds over most of the tropical Pacific, common at-sea species.

Remarks -- Light-phase birds are predominate in the three colonies of the northern Marshalls. Of 489 adults banded October 1964 at Taongi, 93 percent were light phase. All individuals observed in the small colonies at Bikar and Taka were also light phase.

Puffinus griseus Sooty Shearwater

Status -- Accidental island visitor, common at-sea migrant in the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Eniwetok. At-sea: Marshalls - two individuals seen near Majuro June 1966; seen migrating northward through the area April 1967; Gilberts - numerous between Maiana and Kuria migrating southward November 1964.

Pacific Distribution -- Breeds on islands of New Zealand and Australia, as well as along southern coast of South America; migrates through the tropical Pacific during the nonbreeding season.

Remarks -- At sea this species may be confused with the Slender-billed Shearwater.

Puffinus tenuirostris Slender-billed Shearwater

Status -- Accidental on islands in the Marshalls, common at-sea migrant in the Marshall-Gilbert Area.

Marshall-Gilbert Distribution Records -- Marshalls - Arno, Eniwetok. At-sea: Marshalls - one individual seen near Majuro June 1966; seen migrating northward through the area April 1967; Gilberts - migrating southward between Maiana and Kuria November 1964.

Pacific Distribution -- Breeds on islands near and along the coast of Australia; migrates through the tropical Pacific during nonbreeding season.

Remarks -- At sea this species may be confused with the Sooty Shearwater.

Puffinus nativitatus Christmas Shearwater

Status -- Resident breeder in extreme northern Marshalls; visitor to Gilberts.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi. Other: Marshalls - Bikar, Mili. At-sea: Marshalls - one seen near Taka October 1964, present between Taka and Bikar as well as east of Taongi and Bikar during April 1967; Gilberts - reported by Finsch in 1880; one seen off Nonouti July 1963 (Morris, 1963).

Pacific Distribution -- Breeds on the Marshall, Hawaiian, Line, Phoenix, Henderson, Ducie, Tuamotu, and Austral Islands. Bred formerly on Bonin, Marcus, and Wake Islands.

Puffinus assimilis Little Shearwater

Status -- Accidental in the northern Marshalls.

Marshall-Gilbert Distribution Records -- Marshalls - Taongi.

Pacific Distribution -- Breeds in the Austral and Kermadec Islands, as well as on the islands around New Zealand and Australia; normally occurs at sea north to 26° S; one record from Midway Atoll in the Leeward Hawaiian Islands (Clapp and Woodward, 1968).

Puffinus lherminieri Audubon's Shearwater

Status -- At-sea visitor in the Gilbert Islands.

Marshall-Gilbert Distribution Records -- At-sea: Gilberts - Finsch (1880) reported one individual apparently of this species (Bourne *in* Morris, 1963).

Pacific Distribution -- Breeds on most tropical Pacific island groups, excluding the Hawaiian, Marshall, Gilbert, and Ellice Islands. Usually ranges within 100 miles of breeding islands.

HYDROBATIDAE Storm Petrels

Storm petrels are small seabirds which superficially resemble the small gadfly petrels. They are, however, smaller, have longer legs, and their nostrils are united into one tube. Two storm petrels are known from the Gilbert Islands area. One of these species is a possible breeder in the Gilberts; the other species is a migrant to the Gilbert area from the far North Pacific. One storm petrel, a migrant from the North Pacific, is known from the Marshall Islands.

Oceanodroma leucorhoa Leach's Storm Petrel

Status -- At-sea migrant through the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- At-sea: Marshalls - storm petrels, possibly of this species, seen offshore Eniwetok May 1962 (Woodbury, 1962). Gilberts - 12 birds,possibly of this species, seen between Makin and Maiana November 1964.

Pacific Distribution -- Breeds along the Asian and North American continents south to the tropics and north to the Aleutian Islands; migrates to the tropical central Pacific south to 15° S. latitude.

Nesofregetta albigularis White-throated Storm Petrel

Status -- Possible resident breeder in the southern Gilberts.

Marshall-Gilbert Distribution Records -- Gilberts - Tabiteuea.

Pacific Distribution -- Breeds in the Marquesas, Line, Phoenix, Fiji, and New Hebrides Islands.

PHAETHONTIDAE Tropicbirds

Tropicbirds are medium-sized seabirds (almost all white) with extremely long, narrow central tail feathers (immatures have shorter or no central tail feathers), stout bodies, long narrow wings, and a stout pointed bill. All three species of tropicbirds have been recorded from the Marshall-Gilbert area. Two of these breed in the Marshalls. Three species are known in the Gilberts; two are possible breeders (although one of these has been recorded only at sea); one species is a vagrant from the eastern Pacific.

Phaethon aethereus Red-billed Tropicbird

Status -- Old sighting doubtful; if correct, a vagrant to the Gilbert Islands area.

Marshall-Gilbert Distribution Records -- At-sea: Gilberts - Finsch's (1880) early records probably are erroneous identifications of the Red-tailed Tropicbird.

Pacific Distribution -- Breeds on islands off the coast of Central and South America; a rare straggler in the central and western Pacific. Only two specimen records (both Leeward Hawaiian Islands) for islands west of its breeding range.

Phaethon rubricauda Red-tailed Tropicbird

Status -- Resident breeder in the northern Marshalls; possible resident breeder in the Gilberts; occurs at sea within its breeding area.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar, Taka, Eniwetok. Other: Marshalls - Erikub, Mili; Gilberts - Onotoa. At-sea: Marshalls - occurs near breeding islands, no recent sighting elsewhere; Gilberts - Finsch's (1880) records of the Red-billed Tropicbird probably should refer to this species; no recent records.

Pacific Distribution -- Breeds throughout the low islands of the tropical Pacific.

Phaethon lepturus White-tailed Tropicbird

Status -- Resident breeder in the Marshall Islands; known only from at-sea in the Gilberts area.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Bikar, Erikub, Eniwetok, Jaluit. Other: Marshalls - Taongi, Utirik, Jemo, Namorik. At-sea: Marshalls - one just north of, and one south of, Jaluit November 1964; Gilberts - one 30 miles west of Tarawa July 1963 (Morris, 1963), one just south of Makin November 1964.

Pacific Distribution -- Breeds on most island groups in the tropical Pacific where tree-holes or cliffs are available.

SULIDAE Boobies

Boobies are fairly large seabirds whose heavy tapering bodies are supported by long pointed wings and tails. They have long muscular necks with large pointed bills. Three species of boobies breed in the Marshall Islands. One of these species also breeds in the Gilbert Islands, another is a possible breeder, while the other is only a visitor.

Sula dactylatra Blue-faced Booby

Status -- Resident breeder in extreme northern Marshalls; visitor to the Gilberts.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar. Other: Gilberts - Makin, Nikunau. At-sea: Marshalls - occurs near breeding islands; Gilberts - one seen 8 miles east of Tarawa December 1962 (Morris, 1963).

Pacific Distribution -- Breeds on most tropical Pacific island groups, except for those in the extreme southwest and northwest.

Sula sula Red-footed Booby

Status -- Resident breeder in the Marshalls and southern Gilberts.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar, Taka, Jemo, Erikub, Mili, Bikini, Jaluit; Gilberts - Onotoa. Other: Marshalls - Likiep, Majuro, Eniwetok, Rongelap, Ailinginae, Ujae, Kwajalein, Namu; Gilberts - Makin, Abaiang, Tabiteuea. At-sea: Marshalls - several 20 miles east of Eniwetok 7 January 1945 (Baker, 1951); common throughout the area, especially near breeding colonies, October-November 1964, June 1966, and April 1967.

Pacific Distribution -- Breeds in or visits most tropical Pacific island groups.

Sula leucogaster Brown Booby

Status -- Resident breeder in the Marshalls; possible breeder in the Gilberts.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Bikar, Jemo, Likiep, Erikub, Mili, Eniwetok, Jaluit. Other: Marshalls - Taongi, Taka, Majuro, Bikini, Ailinginae, Wotho, Ujae, Kwajalein; Gilberts - Makin, Nonouti, Tabiteuea. At-sea: Marshalls - few 20 miles east of Eniwetok 7 January 1945 (Baker, 1951); one at 07° N x 166° E on 1 November 1960 (Bruyns, 1964); present in small numbers between Bikar and Jemo and south of Jaluit October-November 1964; near Majuro and Kwajalein June 1966; Gilberts - throughout the area November-December 1962, July-August 1963 (Morris, 1963), two seen between Makin and Maiana November 1964.

Pacific Distribution -- Breeds in or visits most island groups in the tropical Pacific.

FREGATIDAE Frigatebirds

Frigatebirds are large but lightweight seabirds, with deeply forked tails, whose long-angled wings support medium-sized bodies. Their long slender bills are greatly hooked. Two species occur in the Marshall and Gilbert Islands. One breeds in the Marshalls, while the other is a visitor from the Gilberts or the Phoenix Islands. One species breeds and the other is a possible breeder in the Gilbert Islands.

Fregata minor Great Frigatebird

Status -- Resident breeder in the Marshalls; possible breeder in the Gilberts.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar, Mili. Other: Marshalls - Taka, Ailuk, Jemo, Likiep, Erikub, Eniwetok, Ujelang, Bikini, Rongerik, Rongelap, Ailinginae, Wotho, Ujae, Kwajalein, Namu, Jabwot, Jaluit; Gilberts - Makin, Maiana, Kuria, Onotoa, Arorae. At-sea: Marshalls - present between Kwajalein and Jaluit November 1964, near all islands visited April 1967; Gilberts - present north of Makin and between Maiana and Kuria November 1964.

Pacific Distribution -- Breeds in or visits most island groups in the tropical Pacific.

Fregata ariel Lesser Frigatebird

Status -- Resident breeder in the Gilberts, regular visitor to the Marshalls.

Marshall-Gilbert Distribution Records -- Breeding: Gilberts - Nonouti, Onotoa. Other: Marshalls - Erikub, Mili, Jaluit; Gilberts - Makin, Tarawa, Maiana, Tabiteuea, Tamana, Arorae. At-sea: Gilberts - very common (Morris, 1963).

Pacific Distribution -- Breeds in most south and south-central Pacific island groups; migrates through the Marshall-Gilbert area to the western Pacific.

STERCORARIIDAE Skuas and Jaegers

Skuas and jaegers are quite large, heavy-set birds with a slightly hooked bill and narrow angled wings. Adult jaegers possess slightly elongated central tail feathers; immatures lack these. Skuas are larger than jaegers and have very heavy bodies. Two species occur in the area: one in the Gilberts and one (possibly both) in the Marshalls. Both are migrants from Arctic or Antarctic areas.

<u>Catharacta skua</u> Great Skua

Status -- Uncommon at-sea migrant in the Marshall (?) and Gilbert Islands.

Marshall-Gilbert Distribution Records -- At-sea: Finsch (1880d) reported a skua in the Gilberts (Bourne <u>in</u> Morris, 1963), no recent records.

Pacific Distribution -- Breeds on Antarctica, in the New Zealand area, and on the southern tip of South America; migrates into the central, north, and far western Pacific.

<u>Stercorarius</u> sp. Jaeger

An unidentified <u>Stercorarius</u> species was observed by POBSP personnel October 1964 at Taka Atoll, Marshall Islands. It is considered to be an accidental in the Marshalls and a migrant in the area. This jaeger could be one of three species: <u>Stercorarius pomarinus</u>, which breeds in the Arctic regions of Asia and North America, and is a migrant to Japan and throughout the central Pacific; <u>S. parasiticus</u>, which is an uncommon migrant in the tropical western Pacific, is not known from the central Pacific, but is a common migrant along the continental coasts; <u>S. longicaudus</u>, which is an Arctic breeder and migrates through the tropical Pacific.

LARIDAE Gulls, Terns, and Noddies

Gulls are medium- or large-sized seabirds whose moderately long wings support stocky bodies. These normally coastal birds have rounded tails and robust pointed bills. Most tend to follow ships. No gulls have been recorded from the Marshall and Gilbert Islands.

Terns and noddies are small and slim, are similar to gulls, and possess long, slender, pointed wings. These normally offshore and pelagic birds usually have forked tails and slender pointed bills. Eleven terns and noddies have been recorded from the Marshall-Gilbert area. Seven (possibly eight) species are resident breeders in the Marshall Islands; three other species are accidentals. Six species are resident breeders in the Gilbert Islands; one species is a visitor from the Marshalls.

<u>Sterna hirundo nigripennis</u> Common Tern

Status -- Accidental on islands and a possible vagrant to the Marshall area.

Marshall-Gilbert Distribution Records -- <u>Marshall</u> - Jaluit.

Pacific Distribution -- Breeds in western Asia, away from the Pacific, migrates along the Asiatic coast, has been recorded near Marcus, Palau, Bismarck, Solomon, Fiji, and Hawaiian Islands.

Sterna paradisaea — Arctic Tern

Status -- Accidental in the northern Marshall Islands and a possible vagrant to the area.

Marshall-Gilbert Distribution Records -- Marshalls - Eniwetok.

Pacific Distribution -- Breeds in the Arctic, migrates to the South Pacific during nonbreeding season.

Sterna sumatrana — Black-naped Tern

Status -- Resident breeder in the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taka, Erikub, Arno, Eniwetok, Ujae, Jaluit; Gilberts - Makin, Tarawa, Onotoa. Other: Marshalls - Taongi, Bikar, Ailuk, Aur, Majuro, Mili, Ujelang, Bikini, Rongerik, Rongelap, Ailinginae, Wotho, Kwajalein, Namu; Gilberts - Maiana, Kuria, Aranuka, Nonouti. At-sea: Marshalls - very close to atolls, one seen between Taka and Jemo October 1964; Gilberts - one 3 miles north of Aranuka July 1963 (Morris,1963) close to atolls November 1964.

Pacific Distribution -- Breeds on almost all island groups in the tropical western and southwestern Pacific; absent or vagrant east of 180° longitude in the central Pacific.

Sterna lunata — Gray-backed Tern

Status - Possible resident breeder in the northern Marshall Islands; probably a regular visitor in the southern Marshalls and Gilberts.

Marshall-Gilbert Distribution Records -- Marshalls - Taongi, Bikar, Mili, Eniwetok, Kwajalein; Gilberts - Nonouti, Tabiteuea. At-sea: Marshalls - none, probably occurs close to atolls; Gilberts - off northern end of Nonouti December 1962 (Morris, 1963).

Pacific Distribution -- Breeds throughout the central Pacific, as well as on Wake, Tuamotu, and Fiji; migrant or vagrant throughout rest of tropical Pacific.

Sterna fuscata — Sooty Tern

Status -- Resident breeder in the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar, Taka, Eniwetok, Ujalong, Ailinginae, Jaluit; Gilberts - Kuria, Nonouti. Other: Marshalls - Ailuk, Jemo, Mili, Knox, Bikini, Rongerik, Kwajalein; Gilberts - Makin, Aranuka, Onotoa. At-sea: Marshalls - occurred near and between breeding atolls October-November 1964, June 1966, and April 1967; Gilberts - 20 seen between Makin and Maiana November 1964.

Pacific Distribution -- Breeds on most island groups in the tropical Pacific.

Sterna anaetheta Brown-winged Tern

Status -- Accidental on islands and probably an at-sea vagrant in the northern Marshalls.

Marshall-Gilbert Distribution Records -- Marshalls - Bikar.

Pacific Distribution -- Breeds in the Bismarck Archipelago, Solomon Islands, Formosa, Philippines, Australia, and on the Pacific coast of Central and South America; vagrant in most island groups of the western and central Pacific.

Thalasseus bergii Crested Tern

Status -- Resident breeder throughout the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar, Taka, Arno, Eniwetok, Bikini, Ailinginae, Jaluit; Gilberts - Tarawa, Kuria, Onotoa. Other: Marshalls - Utirik, Ailuk, Erikub, Maloelap, Aur, Majuro, Mili, Ujelang, Rongerik, Rongelap, Wotho, Ujae, Lae, Kwajalein; Gilberts - Makin, Marakei, Maiana, Abemama, Aranuka, Nonouti, Tabiteuea, Beru, Nikunau, Arorae. At-sea: none, probably occurs only near atolls.

Pacific Distribution -- Breeds throughout the western and southwestern tropical Pacific, as well as on Society, Tuamotu, and Line Islands; absent from the Phoenix and Hawaiian Islands.

Procelsterna cerulea Blue-gray Noddy

Status -- Resident breeder in the extreme northern Marshalls; not recorded from the Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar. Other: Marshalls - Eniwetok. At-sea: Marshalls - occurred within 10 miles of Taongi and Bikar October 1964 and April 1967, between Bikar and Taka October 1964.

Pacific Distribution -- Breeds on most island groups of the central and southern Pacific.

Anous stolidus Brown Noddy

Status -- Resident breeder throughout the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar, Taka, Jemo, Erikub, Eniwetok, Ujelang, Bikini, Rongerik, Rongelap, Ailinginae, Wotho, Ujae, Lae, Kwajalein,Jaluit; Gilberts - Makin, Marakei, Tarawa, Maiana, Kuria, Aranuka, Onotoa. Other: Marshalls - Ailuk, Likiep,

Wotje, Aur, Majuro, Arno, Mili, Namu, Jabwot; Gilberts - Abemama, Nonouti, Tabiteuea, Beru, Nikunau, Arorae. At-sea: Marshalls - one off Kili at 169° E on 2 November 1960 (Bruyns, 1964); very common species around each atoll and throughout the area October-November 1964, June 1966, April 1967; Gilberts - common up to 50 miles from land throughout area November-December 1962 and July-August 1963 (Morris, 1963), seen around atolls and throughout area visited November 1964.

Pacific Distribution -- Breeds, with the exception of the Kermadec Islands, throughout the tropical Pacific.

Anous tenuirostris Black Noddy

Status -- Resident breeder throughout the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar, Taka, Jemo, Erikub, Arno, Eniwetok, Ujelang, Bikini, Rongelap, Ailinginae, Wotho, Ujae, Kwajalein, Namu, Jaluit; Gilberts - Makin, Kuria, Nonouti, Tabiteuea, Onotoa. Other: Marshalls - Ailuk, Wotje, Aur, Majuro, Mili, Rongerik, Lae, Ailinglapalap, Namorik, Ebon; Gilberts - Marakei, Tarawa, Maiana, Abemama, Aranuka, Beru, Nikunau, Arorae. At-sea: Marshalls - most common species throughout area October-November 1964, common June 1966, second most prominent species in area visited April 1967; Gilberts - most common bird throughout the island group November-December 1962 and July-August 1963 (Morris, 1963), most common throughout northern area November 1964.

Pacific Distribution -- Breeds in most tropical Pacific island groups, except those in the northwest and southeast sectors.

Gygis alba White Tern

Status -- Resident breeder throughout the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Taongi, Bikar, Utirik, Taka, Ailuk, Jemo, Erikub, Eniwetok, Bikini, Rongerik, Rongelap, Wotho, Ujae, Kwajalein, Jaluit; Gilberts - Makin, Kuria, Onotoa. Other: Marshalls - Mejit, Likiep, Wotje, Aur, Majuro, Arno, Mili, Ujelang, Ailinginae, Lae, Namu, Jabwot; Gilberts - Marakei, Tarawa, Maiana, Abemama, Aranuka, Nonouti, Tabiteuea, Beru, Nikunau. At-sea: Marshalls - two singles observed off Mili at 172° E on 2 November 1960 (Bruyns, 1964), second most common species throughout the area October-November 1964, very common June 1966, most common species throughout the northern and central area April 1967; Gilberts - common within 10 miles of most atolls during November-December 1962 and July-August 1963 (Morris, 1963), most common species in northern area November 1964.

Pacific Distribution -- Breeds on most island groups of the tropical Pacific.

LAND AND FRESH-WATER BIRDS

Thirty-nine land and fresh water bird species have been recorded in the Marshall Islands, while 19 have been recorded in the Gilbert Islands (Table 38). Twenty-three are known solely from the Marshalls and three are known solely from the Gilberts. Sixteen landbird species are recorded from both island groups.

Two land and fresh water bird species (one introduced) are resident breeders on both island groups (Table 38); one species, a resident breeder in the Marshalls is a probable breeder in the Gilberts. One extinct and two introduced breeders (plus one introduced possible breeder) are found solely in the Marshalls; one introduced breeder (plus one possible breeder) are found solely in the Gilberts. Of seven introduced landbird species only one does not breed in the Marshalls or Gilberts.

Seventeen land and fresh-water bird species (Table 38) are known to migrate annually to or through the Marshall-Gilbert area from distant breeding grounds. These birds, unlike seabird migrants, are attracted to the various atolls and sometimes use them as "stepping-stones" in crossing the Pacific. Sixteen (all shorebirds) of these migrants breed in the Northern Hemisphere, while one (a cuckoo) breeds in the Southern Hemisphere.

Fifteen landbird species found in the Marshall-Gilbert area are vagrants to the area, since they are away from their normal migration routes, and are considered accidentals to island avifauna (Table 38). Most of these are known from only a few records.

ARDEIDAE — Herons

Herons are large wading birds with long necks, long legs, and long spear-like bills. One heron species is a resident breeder throughout the Marshalls and Gilberts.

Egretta sacra — Reef Heron

Status -- Resident breeder in the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Arno, Mili, Eniwetok, Jaluit; Gilberts - Tarawa, Nonouti, Onotoa. Other: Marshalls - Taongi, Bikar, Taka, Ailuk, Jemo, Likiep, Wotje, Erikub, Maloelap, Majuro, Ujelang, Bikini, Rongelap, Ailinginae, Wotho, Ujae, Lae, Kwajalein, Jabwot; Gilberts - Makin, Marakei, Maiana, Abemama, Kuria, Aranuka, Tabiteuea, Beru, Nikunau, Arorae.

Pacific Distribution -- Occurs along the Asian coast from Japan south to Malaysia and on most islands in the southwest Pacific. Breeds throughout its range (Mayr, 1945; Baker, 1951).

Remarks -- Three color phases exist: white, blackish-gray, and mottled.

ANATIDAE Geese and Ducks

Geese and ducks are large waterfowl with heavy bodies, long necks, and webbed feet. Their bills are thick at the base. One goose species, an accidental, has been collected in the Marshall Islands; none are known from the Gilberts. Ten duck species are known from the Marshalls; three are known from the Gilberts (Table 38). Of the 10 duck species in the area, one is an introduced breeder, two are migrants, and seven are accidentals. Of the nine migrants, six breed in both the Old and New World, two breed in the Old World, and one is a New World breeder; one is unknown.

Chen hyperborea Snow Goose

Status -- Accidental in the Marshalls.

Marshall-Gilbert Distribution Records -- Marshalls - Erikub.

Pacific Distribution -- Breeds in the arctic circumpolar region; winters along eastern coast of North America to the northern coast of the Gulf of Mexico and the valleys of California; in western Pacific to Korea and Japan. One record in Hawaii (AOU, 1957; Udvardy, 1961) and one in the Marshalls.

Anas platyrhynchos Mallard

Status -- Accidental in the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Kwajalein; Gilberts - Tarawa.

Pacific Distribution -- Breeds in the northern section of the Northern Hemisphere; winters south to Central America, Africa, and southern Asia; migrates regularly to Hawaii; introduced in New Zealand (AOU, 1957); also frequents Bonin and Volcano Islands (Yamashina, 1948; Baker, 1951). Known from the Marshalls and Gilberts.

Anas crecca Common Teal

Status -- Accidental in the Marshall Islands.

Marshall-Gilbert Distribution Records: Marshalls - Kwajalein, Jaluit.

Pacific Distribution -- Breeds across Eurasia and North America; winters south to Africa, southeastern Asia, and Central America. Known from the Philippines, Japan, the Marianas, Marshalls, Hawaiian, and Line Islands

(Baker, 1951; AOU, 1957; Clapp and Sibley, 1967). Two races exist: (1) _A. c. crecca_, the European Teal of Europe and Asia, and (2) _A. c. carolinensis_, the Green-winged Teal of North America.

Anas strepera Gadwall

Status -- Accidental in the northern Marshalls.

Marshall-Gilbert Distribution Records -- _Marshalls_ - Kwajalein.

Pacific Distribution -- Breeds in northern North America and Eurasia; winters south to Central America, Africa, and southeast Asia. Known from Hawaii (AOU, 1957; Bryan, 1958) and the Marshalls.

Anas penelope European Widgeon

Status -- Accidental to the Marshalls.

Marshall-Gilbert Distribution Records -- _Marshalls_ - Jaluit.

Pacific Distribution -- Breeds in Iceland and northern Eurasia; winters south to Africa, southern Asia, the Philippines, and the southern part of North America. Known from the Marianas, Caroline, Marshall, Hawaiian, and Line Islands (AOU, 1957; Clapp and Sibley, 1967 ; Clapp and Woodward, 1968).

Anas acuta Pintail

Status -- Uncommon migrant in the Marshalls.

Marshall-Gilbert Distribution Records -- _Marshalls_ - Taongi, Kwajalein, Jaluit.

Pacific Distribution -- Breeds in the northern section of the Northern Hemisphere; winters to South America, Africa, and southeast Asia. Known from the Philippine, Marianas, Palau, Marshall, and Hawaiian Islands (Baker, 1951; AOU, 1957).

Anas clypeata Northern Shoveler

Status -- Uncommon migrant in the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- _Marshalls_ - Kwajalein; _Gilberts_ - Makin, Tarawa.

Pacific Distribution -- Breeds in northern North America and Eurasia; winters south to Central America, southern Europe, and southern Asia. Known from the Philippine, Marianas, Caroline, Marshall, Gilbert, Hawaiian, Line, and Phoenix Islands (AOU, 1957; Clapp and Sibley, 1967; Clapp and Woodward, 1968).

Aythya valisineria Canvasback

Status -- Accidental to the Marshall Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Jaluit.

Pacific Distribution -- Breeds in northern North America; winters south to Central America. Known from Japan and the Marshalls (Baker, 1951; AOU, 1957).

Aythya fuligula Tufted Duck

Status -- Accidental in the Marshalls.

Marshall-Gilbert Distribution Records: Marshalls - Kwajalein.

Pacific Distribution -- Breeds in Iceland and Eurasia; winters south into Africa and southeast Asia and the Philippines. Known from the Aleutian, Marianas, Palau, Caroline, and Hawaiian Islands (Baker, 1951; AOU, 1957; Clapp and Woodward, 1968), and the Marshalls.

Cairina moschata Muscovy Duck

Status -- Introduced breeder in the Marshall Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Utirik-Ujelang, Wotho. Other: none, but species possibly occurs on most inhabited atolls.

Pacific Distribution -- Wild: Mexico and South America; Domestic: All over the world (Delacour, 1959).

Anatidae sp. Duck species

An unidentified duck species was observed by POBSP personnel during November 1964 at Jaluit Atoll, Marshall Islands. Another was seen at Makin Atoll, Gilbert Islands. Morris (1963) reported a pair of cormorants in flight over the lagoon at Tabiteuea, Gilbert Islands; he further indicated that these could have been ducks (sp.?); they were in poor light and no details could be seen.

PHASIANIDAE Fowls

There is only one representative of this family in the Marshall-Gilbert area, this being the domestic fowl or chicken. Chickens were introduced into most islands by sea-going Micronesians. In recent times they have probably interbred with other subsequently introduced breeds.

Gallus gallus Domestic Chicken

Status -- Introduced breeder in the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Jabwot; Gilberts: Onotoa. Other: Marshalls - Utirik, Mejit, Ailuk, Jemo, Likiep, Wotje, Maloelap, Aur, Majuro, Arno, Mili, Eniwetok, Ujelang, Rongelap, Wotho, Lae, Jaluit, Namorik, Ebon; Gilberts: Makin, Marakei, Tarawa, Maiana, Abemama, Kuria, Aranuka, Nonouti, Tabiteuea, Beru, Nikunau, Arorae.

Pacific Distribution -- Native to Southeast Asia and Malaysia. Feral fowl from introduced stock are found on most western, southwestern, and south Pacific islands. In the north central Pacific, feral fowl are found only on the main Hawaiian Islands (Mayr, 1945; Baker, 1951; Bryan, 1958).

RALLIDAE Rails

Rails are compact, chicken-like marsh birds with short, rounded wings and short tails. One rail, an accidental species from the western Pacific, has been recorded from the northern Marshalls.

A species of rail was described from the Gilberts. This record is now considered to be in error (see further discussion under Abaiang Atoll).

Poliolimnas cinereus micronesiae White-browed Rail

Status -- Accidental in the northern Marshalls; no recent records.

Marshall-Gilbert Distribution Records: Marshalls - Bikini.

Pacific Distribution -- Occurs in the Marianas and Caroline Islands. Other races are found in the Philippines and Celebes P. c. collingwoodi, and in the Volcano Islands P. c. brevipes (Baker, 1951).

CHARADRIIDAE Plovers

Plovers are compactly built wading birds, with thick necks, moderately short bills, and large eyes. Six species of plovers have been recorded from the Marshall Islands; one species has been recorded from the Gilberts. Of the six species known from the area, five are migrants and one is an accidental (Table 38). Two species are arctic circumpolar breeders, one species is an arctic North American breeder, two species are arctic Old World breeders; the breeding locality of one species is unknown (probably Old World).

Pluvialis dominica Golden Plover

Status -- Common migrant to the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records: Marshalls - Taongi, Bikar, Utirik, Taka, Ailuk, Jemo, Likiep, Erikub, Majuro, Arno, Mili, Eniwetok, Ujelang, Bikini, Rongerik, Rongelap, Ailinginae, Wotho, Ujae, Lae, Kwajalein, Jabwot, Jaluit; Gilberts - Makin, Marakei, Tarawa, Maiana, Abemama, Kuria, Aranuka, Nonouti, Tabiteuea, Beru, Nikunau, Onotoa, Arorae. At sea: Marshalls - five between Bikar and Taka, one between Jemo and Erikub in October 1964.

Pacific Distribution -- Breeds in northern Siberia and Alaska; winters throughout the Pacific south to Australia, New Zealand, and the Tuamotu Islands (AOU, 1957).

Squatarola squatarola Black-bellied Plover

Status -- Uncommon migrant in the northern Marshalls.

Marshall-Gilbert Distribution Records: Marshalls - Eniwetok, Kwajalein.

Pacific Distribution -- Circumpolar breeder in the Northern Hemisphere; migrates along the Pacific coasts of North America and Asia. Recorded from many central, southwestern, and western Pacific island groups (Mayr, 1945; Baker, 1951; AOU, 1957).

Charadrius semipalmatus Semipalmated Plover

Status -- Uncommon migrant in the Marshall Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Jaluit.

Pacific Distribution -- Breeds in high latitudes of North America; winters south to Chile (AOU, 1957). Recorded from central and south-central Pacific (POBSP data), and as far west as the Marshall Islands (Baker, 1951).

Charadrius dubius Ring-necked Plover

Status -- Uncommon migrant in the northern Marshalls.

Marshall-Gilbert Distribution Records: Marshalls - Eniwetok.

Pacific Distribution -- Breeds in northern Europe and Asia; winters from Africa east to the western and southwestern Pacific (Baker, 1951).

Charadrius mongolus Mongolian Plover

Status -- Uncommon migrant in the Marshall Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Majuro, Jaluit.

Pacific Distribution -- Breeds in northeastern Siberia and the Bering Sea area; winters south to Malaysia and Australia and as far east as the Marshall Islands (Mayr, 1945; Baker, 1951).

Charadriinae sp. Plover species

An unidentified sandpiper species was observed by POBSP personnel during November 1964 at Jaluit Atoll, Marshall Islands (see Jaluit Atoll Avifauna Checklist for description). This species is considered to be an accidental in the Marshalls.

SCOLOPACIDAE Sandpipers, et cetera

The family Scolopacidae contains a varied group of small- to medium-sized wading birds. In general, they have long slender legs. Their bills are more slender than those of the plovers. Thirteen species have been recorded from the area, all were found in the Marshall Islands; eight species have been recorded from the Gilbert Islands. Of the 13 species, nine are migrants and four are accidentals (Table 38). Five species are arctic circumpolar breeders, five species are North American breeders, and three species are Asian breeders.

Numenius phaeopus Whimbrel

Status -- Common migrant in the Marshalls and Gilberts.

Marshall-Gilbert Distribution Records -- Marshalls -Utirik, Wotje, Mili, Eniwetok, Wotho, Ujae, Lae, Kwajalein, Jaluit; Gilberts - Makin, Maiana, Kuria, Onotoa (see Note under Numenius tahitiensis).

Pacific Distribution -- Breeds in eastern Siberia; winters in Europe, Asia, Africa, and throughout the western and southwestern Pacific eastward to the Marshall and Gilbert Islands (Baker, 1951; AOU, 1957).

Numenius tahitiensis Bristle-thighed Curlew

Status -- Common migrant in the Marshalls and Gilberts.

Marshall-Gilbert Distribution Records -- Marshalls - Taongi, Bikar, Utirik, Taka, Ailuk, Jemo, Wotje, Erikub, Maloelap, Majuro, Arno, Mili, Eniwetok, Ujalang, Bikini, Rongerik, Rongelap, Ailinginae, Wotho, Ujae, Kwajalein, Jabwot, Jaluit; Gilberts - Makin, Marakei, Tarawa, Maiana, Abemama, Kuria, Aranuka, Nonouti, Beru, Nikunau, Onotoa, Arorae. Note: A Numenius species, either a curlew or Whimbrel, was seen on Tabiteuea, Gilbert Islands, by Morris (1963).

Pacific Distribution -- Breeds in western Alaska; winters in the central and southern Pacific westward to the Carolines and Marianas (Baker, 1951; AOU, 1957).

Limosa lapponica | Bar-tailed Godwit

Status -- Common migrant in the Marshalls and Gilberts.

Marshall-Gilbert Distribution Records -- Marshalls - Arno, Eniwetok, Kwajalein; Gilberts - Makin, Marakei, Tarawa, Maiana, Abemama, Kuria, Aranuka, Nonouti, Tabiteuea, Beru, Nikunau, Onotoa, Arorae.

Pacific Distribution -- Limosa lapponica baueri breeds in Siberia and northern Alaska; migrates southward through the western and southwestern Pacific, and eastward occasionally to the central Pacific (Baker, 1951; AOU, 1957). Limosa l. lapponica breeds in northern Europe; winters in southern Europe and Africa.

Totanus melanoleucus | Greater Yellowlegs

Status -- Accidental in the Marshall Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Jaluit.

Pacific Distribution -- Breeds in northern North America; winters southward to South America (AOU, 1957). Recorded from the Hawaiian Islands (Clapp and Woodward, 1968), and as far west as the Marshalls (Baker, 1951).

Actitis macularia | Spotted Sandpiper

Status -- Accidental in the Marshall Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Taka.

Pacific Distribution -- Breeds in northern North America; winters south to central South America (AOU, 1957). Known from the Marshalls.

Heteroscelus brevipes | Polynesian Tattler

Status -- Uncommon migrant in the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Eniwetok, Kwajalein; Gilberts - Tarawa.

Pacific Distribution -- Breeds in eastern Siberia; winters throughout the western Pacific south to Australia (Baker, 1951; AOU, 1957), one recorded from the Leeward Hawaiian Islands (Clapp and Woodward, 1968).

Heteroscelus incanum | Wandering Tattler

Status -- Common migrant in the Marshalls and Gilberts.

Marshall-Gilbert Distribution Records -- Marshalls - Taongi, Bikar, Utirik, Taka, Mejit, Ailuk, Jemo, Likiep, Wotje, Erikub, Maloelap, Majuro, Arno, Mili, Eniwetok, Ujelang, Bikini, Rongerik, Rongelap, Ailinginae,

Wotho, Ujae, Lae, Kwajalein, Jabwot, Jaluit; Gilberts - Makin, Marakei, Tarawa, Maiana, Abemama, Kuria, Aranuka, Nonouti, Tabiteuea, Beru, Nikunau, Onotoa, Arorae.

Pacific Distribution -- Breeds in Alaska and northeast Canada; winters southward to South America and throughout most of the Pacific (Baker, 1951; AOU, 1957).

Arenaria interpres Ruddy Turnstone

Status -- Common migrant in the Marshalls and Gilberts.

Marshall-Gilbert Distribution Records -- Marshalls - Taongi, Bikar, Utirik, Taka, Mejit, Ailuk, Jemo, Likiep, Wotje, Erikub, Majuro, Arno, Mili, Eniwetok, Ujelang, Bikini, Rongerik, Rongelap, Ailinginae, Wotho, Ujae, Lae, Kwajalein, Lib, Jabwot, Ailinglapalap, Jaluit; Gilberts - Makin, Marakei, Tarawa, Maiana, Abemama, Kuria, Aranuka, Nonouti, Tabiteuea, Beru, Nikunau, Onotoa, Arorae. At-sea: Marshalls - four between Taka and Jemo in October 1964.

Pacific Distribution -- Circumpolar breeder in the Northern Hemisphere; circumtropical winter range. Found widely in the Pacific as far south as Australia (AOU, 1957).

Capella hardwickii Japanese Snipe

Status -- Accidental in the Marshall Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Kwajalein.

Pacific Distribution -- Breeds in the Kurile Islands and Japan; winters in the area of Australia and New Zealand (Peters, 1934; Yamashina, 1961).

Crocethia alba Sanderling

Status -- Common migrant in the Marshalls, uncommon in the Gilberts.

Marshall-Gilbert Distribution Records -- Marshalls - Taongi, Bikar, Erikub, Eniwetok, Kwajalein, Jaluit; Gilberts - Tarawa.

Pacific Distribution -- Circumpolar breeder in the Northern Hemisphere; winters to the Southern Hemisphere. Found widely in the Pacific (AOU, 1957) as far south as the Line, Phoenix, Gilbert (POBSP data), and Marianas Islands (Baker, 1951).

Erolia melanotos Pectoral Sandpiper

Status -- Uncommon migrant in the Marshall Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Taka.

Pacific Distribution -- Breeds in the Arctic regions of northeastern Siberia and North America; winters to South America. Reported occasionally throughout the Pacific as far south as New Zealand, Australia, and the Caroline Islands (Baker, 1951; AOU, 1957).

Erolia acuminata — Sharp-tailed Sandpiper

Status -- Common migrant in the Marshall and Gilbert Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Eniwetok, Kwajalein, Jaluit; Gilberts - Makin, Tarawa, Kuria.

Pacific Distribution -- Breeds in northern Siberia; winters along western coast of North America and coast of eastern Asia. Recorded frequently from the western and central Pacific and as far south as Australia, Tasmania, and the Tonga Islands (Baker, 1951; AOU, 1957; Clapp and Woodward, 1968).

Tryngites subruficollis — Buff-breasted Sandpiper

Status -- Accidental in the northern Marshalls.

Marshall-Gilbert Distribution Records -- Marshalls - Eniwetok.

Pacific Distribution -- Breeds locally in northwestern North America; winters in central Argentina. Recorded (as casual) in the Kurile Islands, Japan (AOU, 1957), and the Marshalls (Pearson and Knudsen, 1967).

RECURVIROSTRIDAE — Stilts

Stilts are medium-sized, slender wading birds, with very long legs and long slender bills. One stilt (species unknown) has been recorded from the Gilbert Islands. It is an accidental to the area; its breeding ground is unknown.

Himantopus sp. — Stilt species

An unidentified stilt species was observed by POBSP personnel during November 1964 at Makin Atoll, Gilbert Islands. It is considered to be an accidental in the Gilberts.

COLUMBIDAE — Pigeons and Doves

Pigeons and Doves are small, usually plump, fast-flying landbirds, with pointed wings, pointed or rounded tails, and small heads. Pigeons are larger than doves. One pigeon species is a resident breeder in the Marshall Islands and is a probable breeder in the Gilbert Islands. One dove species, now an extinct breeder, was known from the Marshalls. Two dove species, both introduced, occur in the Gilberts - one is a breeder, the other is a possible breeder.

Gallicolumba erythroptera* Ground Dove

Status -- Introduced breeder in the Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Gilberts - Abemama, Nonouti.

Pacific Distribution -- Native to the Society and Tuamotu Islands (Baker, 1951).

*Remarks -- I am using the species designation given by Child (1960), who says this species was reported to have been introduced into the Gilberts from Nauru about 1940. Pearson (1962) did not find any doves at Nauru in 1961.

Gallicolumba stairi* Friendly Ground Dove

Status -- Introduced, possible breeder in the Gilbert Islands.

Marshall-Gilbert Distribution Records -- Gilberts - Abemama.

Pacific Distribution -- Present only at Fiji, Tonga, and Samoa Islands (Peters, 1934).

*Remarks -- I am using the species designation given by Child (1960) who says this species was probably introduced from Fiji.

Ptilinopus porphyraceus hernsheimi* Crimson-crowned Fruit Dove

Status -- Extinct breeder in the Marshall Islands.

Marshall-Gilbert Distribution Records -- Marshalls - Ebon.

Pacific Distribution -- Present only at Kusaie in the Caroline Islands (Ripley and Birckhead, 1942; Baker, 1951).

*Remarks -- This species was described as Ptilinopus marshallianus by Peters and Griscom (1928) from a single adult specimen, sex unknown, collected by the Rev. B. G. Snow in the latter part of 1859.

Ducula oceanica Micronesian Pigeon

Status -- Resident breeder in the southern Marshall Islands, probable breeder in the Gilbert Islands.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Arno, Jaluit. Other: Marshalls - Wotje, Ailinglapalap; Gilberts - Kuria, Aranuka.

Pacific Distribution -- Occurs throughout Micronesia. Five subspecies exist: (1) Ducula oceanica ratakensis is known from the Radak Chain of

the Marshalls; (2) D. o. oceanica is known from Kusaie in the Carolines, the Ralik Chain of the Marshalls, and the Gilberts; (3) D. o. townsendi is known from Ponape in the Carolines; (4) D. o. teraokai is known from Truk, Lukunor, and Nukuoro in the Carolines; and (5) D. o. monacha is known from the Palaus and Yap in the Carolines (Mayr, 1940; Amadon, 1943; Baker, 1951).

PSITTACIDAE Parrots

Parrots form a large group of birds. Despite their great size variation, they all have a short, stout, strongly hooked bill, a short neck, compact body, and strong, rounded wings. Most have brightly colored plumage. One record of a parrot, probably introduced, exists for the Marshall Islands.

Psittacidae sp. Parrot species

An unidentified parrot, probably introduced, was observed by POBSP personnel during June 1966 at Majuro Atoll, Marshall Islands.

CUCULIDAE Cuckoos

Cuckoos are slender, long-tailed landbirds possessing secretive habits. One cuckoo species migrates into both the Marshall and Gilbert Islands from the southwest Pacific.

Urodynamis taitensis Long-tailed New Zealand Cuckoo

Status -- Regular migrant throughout the Gilberts and in the Marshalls up to 12° N latitude.

Marshall-Gilbert Distribution Records -- Marshalls - Likiep, Wotje, Aur, Arno, Mili, Eniwetok, Bikini, Ailinglapalap, Jaluit; Gilberts - Makin, Abaiang, Tarawa, Onotoa.

Pacific Distribution -- Breeds in New Zealand and nearby islands; winters throughout Polynesia, Melanesia, and Micronesia (Mayr, 1945; Baker, 1951).

PLOCEIDAE Weaver Finches

The Ploceidae are a varied group of small birds with thick bills, of which the House Sparrow is the best known. One specimen, probably introduced, and a possible breeder, occurs in the Marshall Islands.

Passer domesticus House Sparrow

Status -- Probably introduced, and a possible breeder in the Marshalls; known from only one atoll.

Marshall-Gilbert Distribution Records -- Marshalls - Kwajalein.

Pacific Distribution -- Native to Eurasia and north Africa. Introduced almost worldwide, including Australia, New Zealand, Hawaii (main islands, Kure, and Midway), and Wake (AOU, 1957; Clapp and Woodward, 1968).

STURNIDAE Mynas

The Sturnidae are a varied family; most are like "blackbirds" in appearance. They are stocky, blackish-brown birds with short tails and sharp bills. They are very gregarious. One species, probably an introduced breeder, now absent, is known from the Marshall Islands.

Acridotheres tristis Indian Myna

Status -- Probably an introduced breeder in the Marshall Islands, now absent; known from only one atoll.

Marshall-Gilbert Distribution Records -- Breeding: Marshalls - Kwajalein.

Pacific Distribution -- Introduced throughout the southwest Pacific, including Fiji, New Caledonia, New Hebrides, and Solomon Islands (Mayr, 1945) and the Marshalls (Fosberg, 1966).

INFLUENCING FACTORS

The average number of bird species found on the 34 islands in the Marshalls is 13.1 per island (Table 40). This figure is very close to the average number of species found on the 16 islands in the Gilberts, which is 12.7 per island (Table 40). From this, one might conclude that avifaunal distribution throughout the Marshall-Gilbert area was uniform.

This is not the case; there is a north to south variation (see N-S Zone, Table 40) in the average total number of bird species per atoll. Using nine, two-degree, north-south zones (Fig. 5, see zone discussion under Vegetation Section) we find that the highest number of species is found in the northernmost zone (Zone 1), where an average of 26 bird species per atoll is found (Fig. 6). In Zone 2, the average is 23 bird species per atoll; in Zone 3 and 4 the average decreases, respectively, from 17 and 14, to a low of 8 bird species per atoll in Zone 5. An increase occurs in Zones 6 and 7 (10 and 12 bird species per atoll, respectively), and further increases to 13 bird species per atoll in both Zones 8 and 9.

The average number of possible breeding species per atoll for each zone also follows a similar pattern: Zone 1 is again highest with 18, Zone 6 is low with 5, and Zone 9 has 8. The average number of migrants per atoll for Zones 1 through 4 and 7 through 9 is 5 or 6 species; two center zones (Zones 5 and 6) average only 3 species. The average number of accidentals and visitors is very low for each zone, but it is highest (2 species) in Zones 1 and 2.

From west to east in the Marshall-Gilbert area (see W-E Zone, Table 40) there is less variation in the average number of bird species per atoll than from north to south. Four west-east zones, each four degrees wide (except for the westernmost which is 5 degrees wide), were used for comparison (Fig. 7). Zone A, the westernmost zone, is highest in: 1) the average total species, 2) the average possible breeding species, and 3) the average migrant species. Zones B, C, and D are similar to one another in these three categories. The average number of visitors and accidentals is very low for each zone, but is highest in Zones A, B, and C (1 species each).

Zone A includes only atolls in north-south Zones 3 and 4, thus the average number of species (in all four categories) is similar for these zones. Similarly, Zone D includes only atolls in north-south Zone 9, thus the average number of species (in all four categories) is identical for these two zones. Zones B and C contain a cross-section of atolls from Zones 1 through 8, thus the species average for Zones B and C is similar to the overall species average for the Marshall-Gilbert area.

The lack of uniformity in species distribution may be traced to a number of environmental factors, among them, topography, climate, vegetation, man and other animals, the surrounding oceans, and food resources.

Table 40. Avifaunal components of each atoll in the Marshall-Gilbert area, arranged from north to south.

Atoll	Possible Breeders	Migrants	Visitors and Accidentals	Total	N-S Zone	W-E Zone
Taongi	18	6	2	26	1	B
Bikar	16	5	2	23	2	C
Bikini	11	5	1	17	3	A
Eniwetok	15	12	5	32	3	A
Rongerik	8	4	0	12	3	B
Rongelap	10	4	0	14	3	B
Utirik	5	5	0	10	3	B
Taka	12	5	2	19	3	B
Ailinginae	10	4	0	14	3	B
Ailuk	9	4	0	13	4	B
Mejit	2	2	1	5	4	C
Wotho	10	5	0	15	4	A
Jemo	10	4	0	14	4	B
Likiep	7	4	0	11	4	B
Ujelang	10	4	0	14	4	A
Wotje	6	5	0	11	4	C
Erikub	12	5	1	18	4	C
Kwajalein	13	11	7	31	4	B
Ujae	9	5	0	14	4	A
Lae	6	4	0	10	4	B
Maloelap	3	2	0	5	4	C
Lib	0	1	0	1	5	B
Aur	6	1	0	7	5	C
Namu	6	0	0	6	5	B
Jabwot	5	4	0	9	5	B
Ailinglapalap	2	2	0	4	5	B
Majuro	9	5	1	15	5	C
Arno	8	6	1	15	5	C
Mili	14	6	2	22	6	C
Knox	1	0	0	1	6	C
Jaluit	15	9	9	33	6	B
Kili	0	0	0	0	6	B
Namorik	3	0	0	3	6	B
Ebon	3	0	0	3	6	B
Marshall Average	274 8.1	139 4.1	34 1.0	447 13.1		

Table 40 (cont.). Avifaunal components of each atoll in the Marshall-Gilbert areas, arranged from north to south

Atoll	Possible Breeders	Migrants	Visitors and Accidentals	Total	N-S Zone	W-E Zone
Little Makin	0	0	0	0	7	C
Makin	12	10	1	23	7	C
Marakei	6	5	0	11	8	C
Abaiang	1	1	0	2	8	C
Tarawa	7	11	1	19	8	C
Maiana	8	7	0	15	8	C
Abemama	8	5	0	13	8	C
Kuria	10	7	0	17	8	C
Aranuka	9	5	0	14	8	C
Nonouti	12	5	0	17	9	D
Tabiteuea	11	5	1	17	9	D
Beru	6	5	0	11	9	D
Nikunau	6	5	1	12	9	D
Onotoa	12	7	0	19	9	D
Tamana	1	0	0	1	9	D
Arorae	7	5	0	12	9	D
Gilbert Average	116	83	4	203		
	7.3	5.2	0.3	12.7		

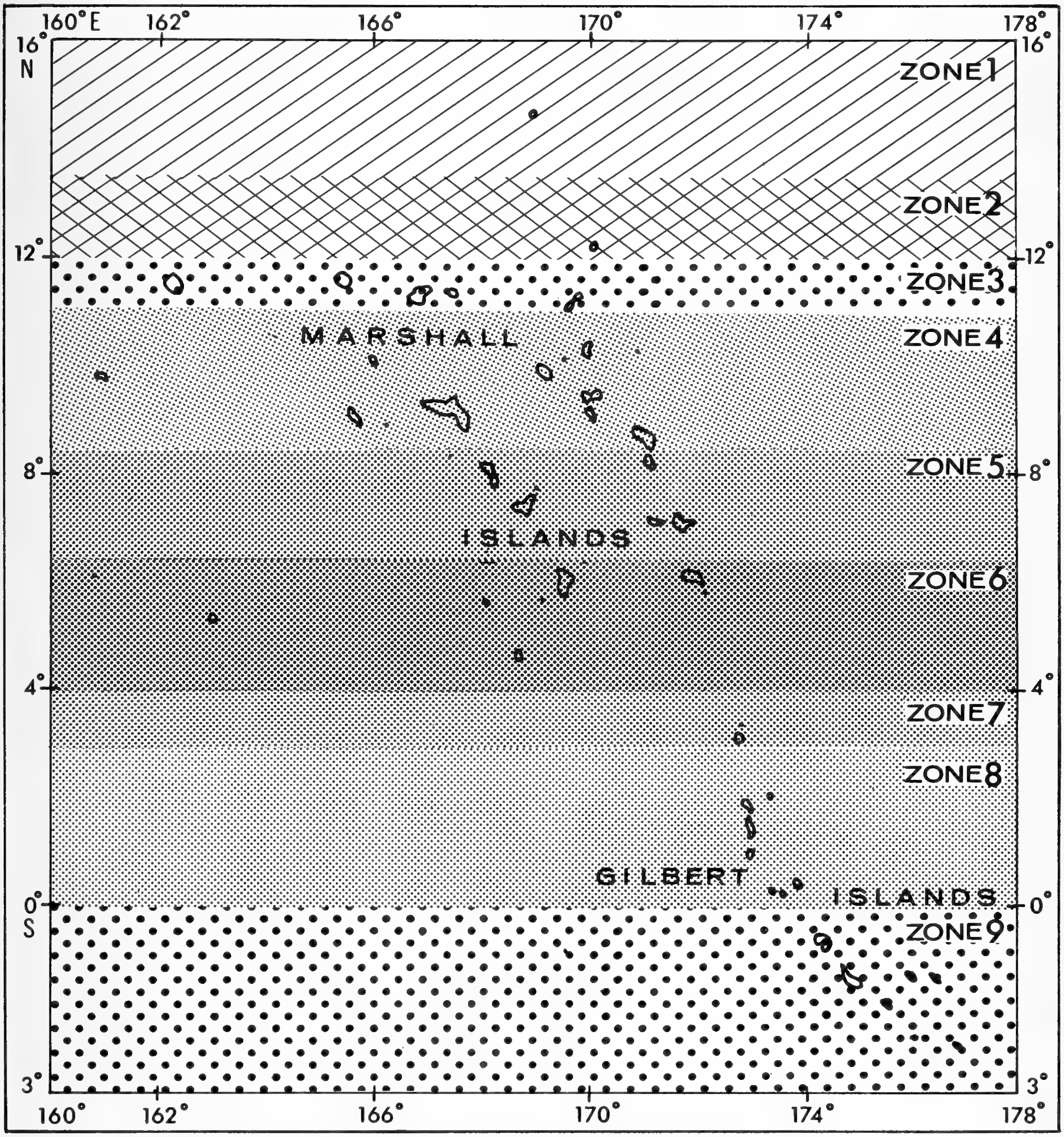


FIGURE 5 Vegetation Zones in the Marshall and Gilbert Islands.
Zones with similar shading have comparable vegetation.

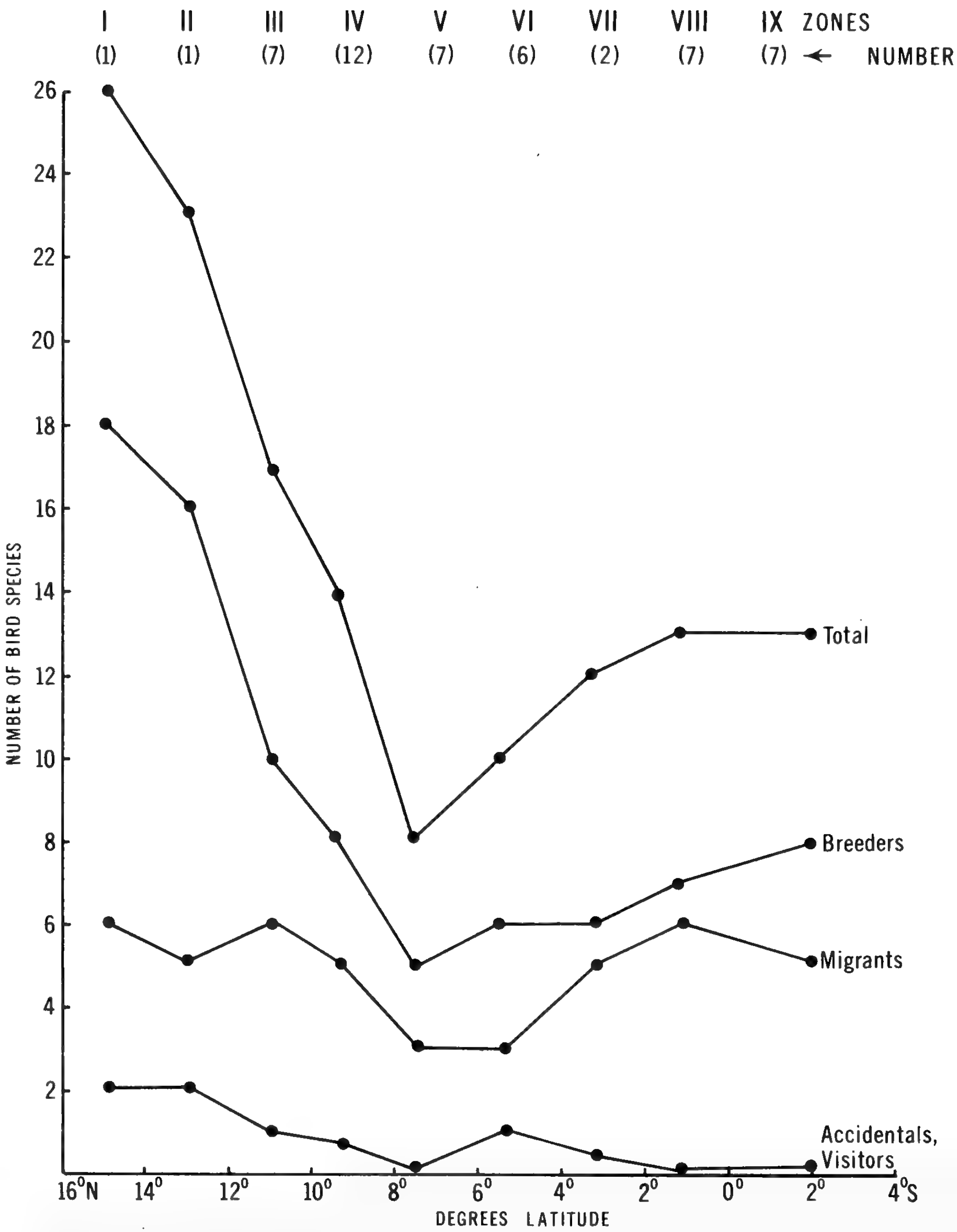


FIGURE 6. North to South Distribution.

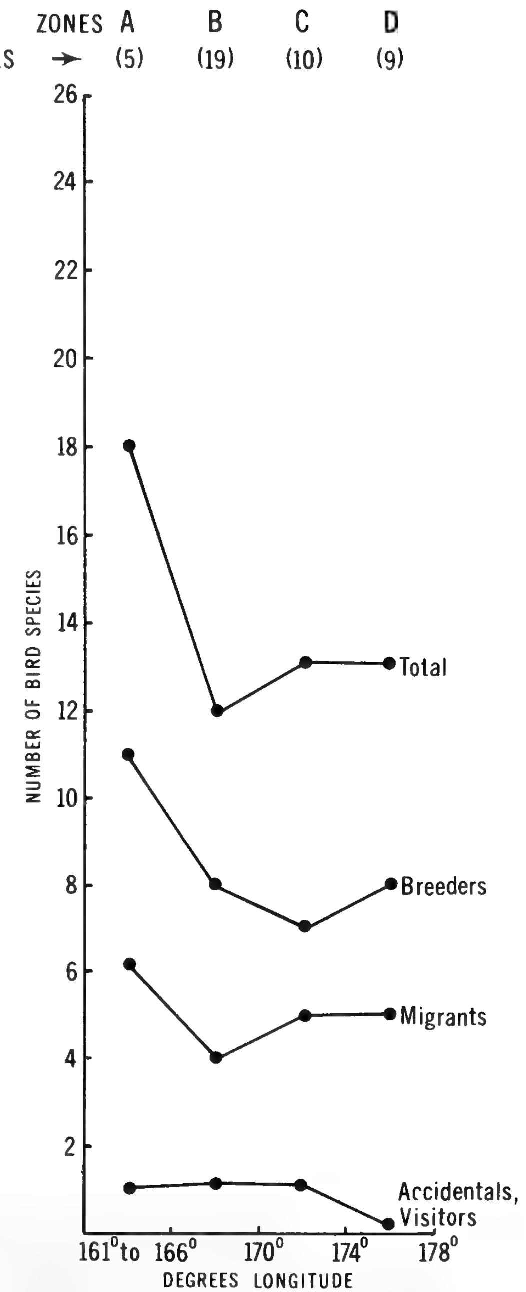


FIGURE 7. West to East Distribution.

Average Number Of Bird Species Per Zone

Topography

The 50 islands comprising the Marshalls and Gilberts are all remnants of former volcanoes or volcanic peaks. All of these volcanic peaks have been completely destroyed and are marked only by low coral rock islands protected by reefs formed by coral growth. Some of these coral exposures possess a lagoon formed by the reef; these are known as coral atolls. Other coral exposures lack lagoons, and are known as coral islands (Baker, 1951; Wiens, 1962). The Marshalls and Gilberts contain 41 coral atolls and 9 coral islands.

All 50 islands and atolls are very low, averaging from 5 to 20 feet in height; a few attain a height of slightly more than 25 feet (U. S. Navy, 1964). The main composition of the elevated portions of all the islands is coral debris and sand; in some areas compact coral rock outcroppings are found (Woodford, 1895; Fosberg, 1956). In general, the eastward, or weather side, of each island rises steeply, whereas the westward, or lee side, slopes gradually (U. S. Navy, 1964).

Although there are only 16 islands in the Gilberts as compared with 34 in the Marshalls, total land area in the Gilberts (114.12 square miles) is much greater than in the Marshalls (70.09 square miles). The land area data for each island are presented in Table 41. In general, the land area increases from north to south. An average Northern Marshall Island (Maloelap and north) has 1.73 square miles of land, while an average Southern Marshall Island (Lib and south) has 2.36 square miles of land. An average Northern Gilbert Island (Aranuka and north) has 6.43 square miles of land, while an average Southern Gilbert Island has 8.02 square miles of land.

Available fresh water throughout the Marshall-Gilbert area varies with the size of the island and the amount of rainfall. Fresh water occurs under the larger islands as a shallow, lens-shaped body floating on the denser sea water. Friction with the porous coral sand retards diffusion of the fresh water into the salt water and helps create this reservoir. It is renewed by rainfall. During dry spells, or in areas where rainfall is low, the fresh water may become brackish (Fosberg, 1956).

Since topographic features are similar throughout the Marshalls and Gilberts, they do not determine bird-species distribution within the area; there may, however, be local topographic variations that influence species distribution on islands and within atolls.

Climate

The climate of the entire Marshall-Gilbert area is marine and tropical in character. The mean annual temperature in the Marshalls is 82° F. and the mean monthly temperature does not vary beyond 2° F. annually. Daily temperature variation is much greater than the annual range (Fosberg,

Table 41. People-land relationship in the Marshall-Gilbert area.

Atoll	N-S Zone	Population 1964	Zone Total	Land Sq./Mi.	Zone Total	People Sq/Mi.	Zone Average
Taongi	1	0		1.45		0	
			0		1.45		0
Bikar	2	0		0.20		0	
			0		0.20		0
Bikini	3	?		2.82		?	
Eniwetok	3	?		2.47		?	
Rongerik	3	0		0.81		0	
Rongelap	3	228		2.46		92.7	
Utirik	3	219		1.04		210.6	
Taka	3	0		0.21		0	
Ailinginae	3	0		1.29		0	
			447		11.10		40.3
Ailuk	4	410		2.19		187.2	
Mejit	4	329		1.32		249.2	
Wotho	4	54		1.60		33.8	
Jemo	4	0		0.07		0	
Likiep	4	546		3.63		150.4	
Ujelang	4	312		0.62		503.2	
Wotje	4	498		3.34		149.1	
Erikub	4	0		0.35		0	
Kwajalein	4	2,663		5.63		473.0	
Ujae	4	230		0.62		371.0	
Lae	4	143		0.60		238.3	
Maloelap	4	636		3.81		166.9	
			5,821		23.78		244.8
Lib	5	190		0.36		527.8	
Aur	5	372		2.17		171.4	
Namu	5	684		2.42		282.6	
Jalwot	5	92		0.22		418.2	
Ailinglapalap	5	1,183		5.67		208.6	
Majuro	5	4,612		3.54		1302.8	
Arno	5	1,301		5.00		260.2	
			8,434		19.38		435.19
Mili	6	602		6.15		97.9	
Knox	6	0		?		0	
Jaluit	6	1,127		4.38		257.3	
Kili	6	287		0.36		797.2	
Namorik	6	534		1.07		499.1	
Ebon	6	953		2.22		429.3	
			3,503		14.18		247.03
Marshalls Total		18,205		70.09			
Marshalls Average		758.5		2.58		259.7	

Table 41 (cont.). People-land relationship in the Marshall-Gilbert area.

Atoll	N-S Zone	Population 1964	Zone Total	Land/ Sq./Mi.	Zone Total	People Sq./Mi.	Zone Average
Little Makin	7	908		2.80		324.3	
Makin	7	2,510		4.50		557.8	
			3,418		7.30		468.2
Marakei	8	1,536		3.94		398.8	
Abaiang	8	2,467		11.06		223.1	
Tarawa	8	3,790		7.73		490.3	
Maiana	8	1,238		10.39		119.2	
Abemama	8	1,498		6.57		228.0	
Kuria	8	430		4.98		86.3	
Aranuka	8	223		5.97		37.35	
			11,182		50.64		220.8
Nonouti	9	2,549		9.82		259.6	
Tabiteuea	9	4,239		19.00		223.1	
Beru	9	2,167		8.15		265.9	
Nikunau	9	1,694		7.00		242.0	
Onotou	9	1,913		5.21		367.2	
Tamana	9	1,092		2.00		546.0	
Arorae	9	1,576		5.00		315.2	
			15,230		56.18		271.1
Gilberts Total		29,830		114.12			
Gilberts Average		1,864.4		7.13		261.4	

1956; Wiens, 1962). Mean maximum temperatures of 88° F. to 90° F. (September-October) usually occur between 1300 and 1400 hours; temperatures of over 100° F. have been recorded. Mean minimum temperatures of 76° F. (September-October) usually occur between 0500 and 0600 hours (Fosberg, 1956; Wiens, 1962). The mean annual temperature throughout the Gilberts is also in the low 80's (84° F. at Makin and 83° F. at Abaiang), with only a slight decrease from north to south (Sachet, 1957).

In the Northern Marshalls the Northeast Trade Winds blow mainly from the east and northeast throughout the year. They are usually constant (18 knots) from December to March and are generally lighter and more variable during the rest of the year. In the Southern Marshalls the Northeast Trade Winds predominate from December to April. They blow with moderate velocity from the east and northeast. During the rest of the year east to southeast winds increase in frequency, becoming predominate in the fall months. Gales are infrequent, but tend to occur in the summer and fall. Calms are rare throughout the entire Marshall area (U. S. Navy, 1962).

There is also some variation in the trade winds between the Northern and Southern Gilberts. In the Northern Gilberts (above 2° N), the islands are influenced by the Northeast Trades between November and March. Apparently the borderline of the Northeast and Southeast Trade Winds is along the 2° N line. In the Northern Gilberts the trades blow from east to just a little southeast, while in the Southern Gilberts the trades blow east-southeast. The Southeast Trade Winds (average 12 knots) predominate during March to November. A westerly season occurs from November to March characterized by an occasional gale (winds up to 50 m.p.h.) lasting from two days to a week. Calms occur quite often in June and July (U. S. Navy, 1952, 1962).

Typhoons are rare in the Marshalls and Gilberts. Only one is known to have crossed the Gilberts, the typhoon of 1927. In the Marshalls only four have been reported since 1900, those of 1905, 1951, 1958 (U. S. Navy, 1952, 1962; Wiens, 1962; Sachet, 1957), and 1967.

Relative humidity is high throughout the Marshalls during all months. At Ujelang, for example, the mean relative humidity is 82 percent; it is somewhat lower during winter and early spring. The relative humidity is higher at night and in early morning than during the day (Fosberg, 1956; U. S. Navy, 1962).

Very little is known about the relative humidity in the Gilberts (Sachet, 1957), but it is undoubtedly very similar to the Marshalls. A known example is Tarawa where the average annual relative humidity is 77 percent (U. S. Navy, 1962).

The sky in both the Marshalls and Gilberts is usually characterized by partial cloudiness throughout most of the year. Clear days are rare and all-cloudy days are uncommon. At Jaluit the average annual cloud cover is slightly over 6/10, while at Majuro it is almost 8/10 (Fosberg, 1956; Sachet, 1957; U. S. Navy, 1962).

Rainfall increases from the Northern to the Southern Marshalls. It decreases from the Northern to Southern Gilberts, with a slight upswing in the southernmost islands (Figure 8). Thus, for example, Wake at 19°17' N and north of the Marshalls, has an average annual rainfall of 37 inches; Eniwetok, at 11°21' N, has an average annual rainfall of 51 inches; Kwajalein, at 08°41' N, has an average annual rainfall of 95 inches; and Jaluit, at 05°55' N, has an average annual rainfall of 159 inches (Fosberg, 1956).

In the Gilberts, Makin, at 03°37' N, has an average annual rainfall of 122 inches; Tarawa, at 01°25' N, has an average annual rainfall of 64 inches; Tabiteuea, at 01°20' S, has an average annual rainfall of 41 inches; and Arorae, at 02°38' S, has an average annual rainfall of 52 inches (Sachet, 1957). Catala (1957) recognizes three rainfall zones in the Gilberts, but he considers rainfall from only one island in each group. He indicates that the rainfall decreases from north to south (North 119", Center 78", and South 43.3") and does not note the slight increase in the southernmost islands.

In the Northern Marshalls, the heaviest precipitation occurs from September through November, while in the Southern Marshalls it is heavy during all months (U. S. Navy, 1962). In the Gilberts the wettest months are from December to August (Sachet, 1957).

The climate affects bird species distribution in the Marshall-Gilbert area, both directly and indirectly. The dry conditions found in the Northern Marshalls are very favorable for most seabird breeding colonies. The very wet conditions of the Southern Marshalls and Northern Gilberts have a deleterious effect upon the breeding of some species since an overabundance of rain can disrupt or destroy an entire colony of ground-nesters, especially during the egg or small chick stage. As a result, Wedge-tailed Shearwaters, Blue-faced Boobies, and Sooty Terns either do not nest, or nest only in small numbers, in this wet area. Since heavy rain usually does not affect tree-nesters, one species, the Brown Noddy, is a ground-nester in the Northern Marshalls and a tree-nester in the Southern Marshalls and Gilberts.

Indirectly, rainfall affects birds by influencing vegetation growth and distribution, and human distribution.

Vegetation

In general, the number of plant species on an atoll varies directly with the amount of rainfall, but, as Wiens (1962) pointed out, this correlation is not always consistent. He suggested that other factors, such as nearness to larger land masses, and the common practice of introductions by man, play a role. Marshall-Gilbert vegetation is an example of such a complex distribution pattern.

Taylor (1950) pointed out that the Southern Marshalls contained species different from those of the Northern Marshalls. Fosberg (1956)

348-415 O-69—22

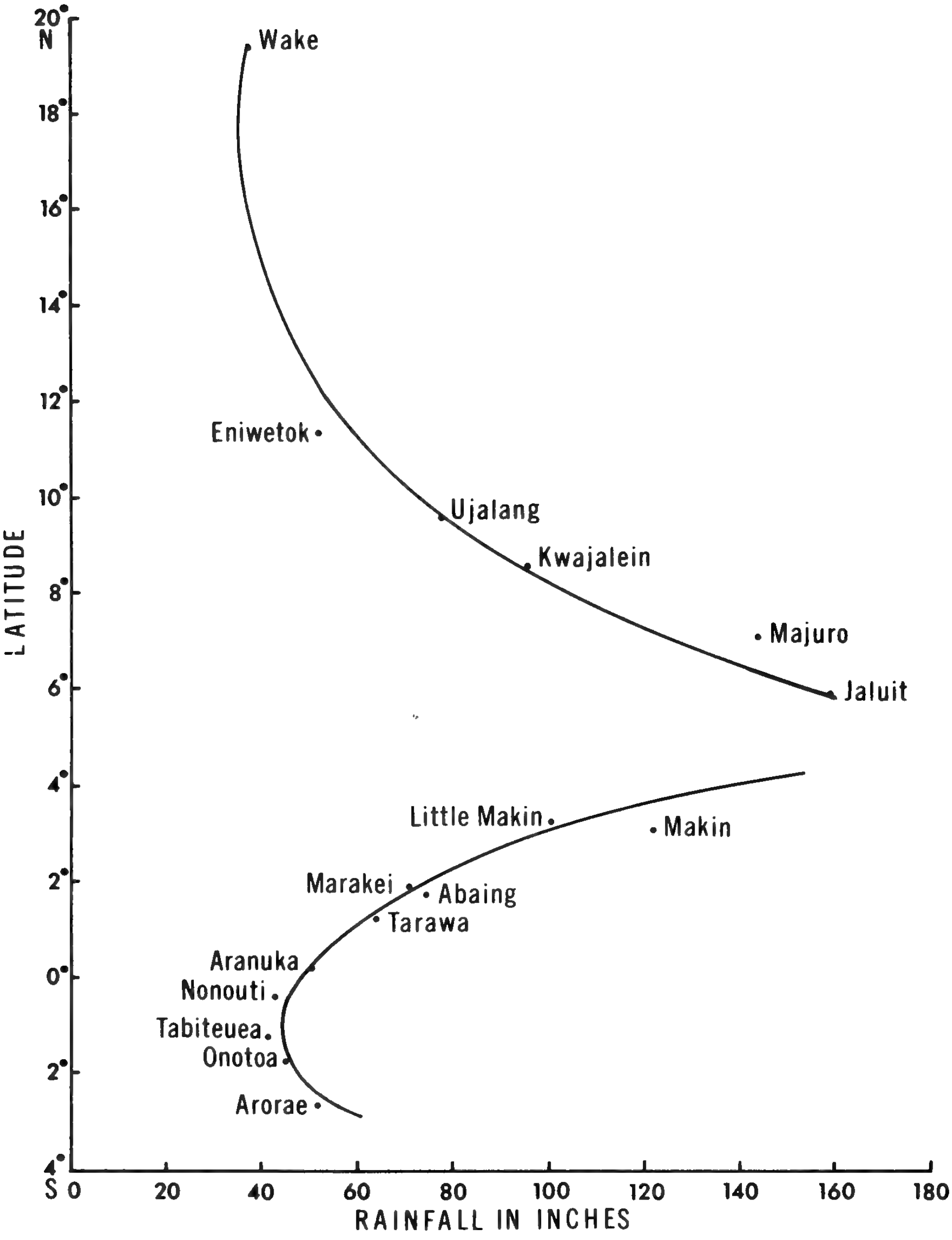


FIGURE 8. Variation of Rainfall with Latitude in the Marshall and Gilbert Area.

recognized four vegetation zones in the Northern Marshalls, each running in an east-west belt, and arranged from north to south corresponding to increasing degrees of wetness (Figure 5, Zone 1-4).

The northernmost belt (Zone 1), containing only Taongi (and Wake north of the Marshalls), is so arid that coconut does not thrive well. One small tree was seen in April 1967. The plant species are few and the island appears very bare. Low scrub forest makes up most of the cover; much open ground, composed of loose stones and sand covered with grass and scattered morning-glories, can be found.

The second belt (Zone 2),consisting also of one atoll, Bikar, is slightly wetter and will support coconut trees, but during dry periods normal nuts will not develop. As in Zone 1, the number of plant species is very low, but here the dominant vegetation is a pure Pisonia forest composed of large trees whose crowns form a complete canopy.

The third belt (Zone 3) consists of 7 atolls, from Eniwetok in the west to Utirik in the east, between 12° N and 11° N. This zone has a more diverse vegetation and a larger number of plants, including, in addition to those of Zones 1 and 2, Cordia forest, Pemphis forest, and mixed forest. Coconuts have been planted on the larger islands, but their growth is sparse and they usually produce rather small nuts. During the dry season the general aspect of the atolls in Zone 3 is quite drab.

The fourth belt (Zone 4) consists of 12 atolls, from Ujelang in the west to Maloelap in the east, between 11° N and 08°30' N. Zone 4 is characterized by a much more luxuriant appearance and a greater diversity of species than Zones 1, 2, and 3. Of particular note are the pure forests of Ochrosia and the occurrence of many introduced plants. Coconut plantations are extensive throughout Zone 4; breadfruit trees often predominate in the neighborhood of native villages.

In the Southern Marshalls Wiens (1962) distinguished between two additional zones (Figure 5, Zone 5-6). Zone 5 includes 7 atolls, all lying between 08°30' N and 06°30' N. It is characterized by moderately heavy rainfall; the vegetation is extremely luxuriant (more so than in Zone 4). Coconut trees are thick, very tall, and produce excellent copra. Breadfruit trees are also very tall. Undercover vegetation is very thick.

The southernmost vegetation belt in the Marshalls, Zone 6, comprises 6 atolls, situated between 06°30' N and 04° N. Zone 6 is characterized by very heavy rainfall and extremely luxuriant vegetation. This zone, because of heavy rainfall and numerous plant introductions by man, especially on Jaluit, probably contains the largest number of plant species in the Marshalls, even though many plants at Jaluit were destroyed by the January 1958 typhoon.

Catala (1957) divided the Gilberts into three rainfall zones. Wiens (1962) suggested that these would presumably be reflected in the vegetation, but pointed out that Catala divided the coconut palm into only two

zones - a northern zone (Zones 1 and 2) and a southern zone (Zone 3). Wiens declined further comment on Gilbert vegetation zones due to insufficient data. POBSP vegetation data obtained during the November 1964 visit to four of the northern Gilberts, and vegetation studies by Luomala (1953), Moul (1957), and Catala (1957) substantiate the idea of vegetation zones (Figure 5, Zones 7-9) coinciding with the three rainfall zones.

The two northernmost Gilbert Islands (Zone 7), between 04° N and 03° N, are characterized by an extremely luxuriant flora, comparable to that of Zone 5 in the Marshalls. Both zones have moderately heavy rainfall. The coconut trees in Zone 7 are generally very thick and tall, and copra production is high. Other trees are also very high; the undercover vegetation is very thick.

The eighth vegetation belt (Zone 8) in the Marshall-Gilbert area, consisting of 7 Gilbert atolls, is located between 03° N and 0°, and is characterized by a very luxuriant appearance. Zone 8 is comparable to Zone 4 of the Marshalls. The extensive coconut plantations are not quite as thick and tall as in the more northern Gilberts (Zone 7). Even though Zone 8 is drier than Zone 7, it has more recorded plant species. This is mainly due to the number recorded at Tarawa which has had many foreign plant introductions and more botanical studies. In general, this zone also has sparse undercover vegetation, but on some atolls and in some spots (especially around inland ponds, taro pits, etc.) this undergrowth is very thick.

The southernmost vegetation belt (Zone 9) in the Marshall-Gilbert area consists of the 7 islands located in the Southern Gilberts between 0° and 03° S. This zone is characterized by having most of the land covered with medium-sized coconut trees. The coconut groves range from dense, to thin, irregular and scattered trees. Undercover growth is thicker in the sparse groves. This zone probably compares similarly to Zone 3 of the Marshalls.

Vegetation, both in number of species and in amount, greatly affects the bird distribution in the Marshall-Gilbert area. The few plant species and low, scattered, scrub forest of the Northern Marshalls is very favorable for both ground- and tree-nesting bird species. As the plant species increase in number and amount from north to south, the number of bird species decreases. The high number of plant species coupled with luxuriant growth in the Southern Marshalls and Northern Gilberts is favorable only for the tree-nesting bird species.

Ocean Currents

The ocean current system in the region of the Marshall and Gilbert Islands consists primarily of the westward moving North and South Equatorial Currents, and the Equatorial Countercurrent that sets eastward between them. The North Equatorial Current (generally above 9° N) is usually weaker than the South Equatorial Current (generally below 4° N) It averages about 0.4 knots (with flow up to 2 knots). The South

Equatorial Current may reach a velocity of 3 to 4 knots. Eastward sets may occur in both Equatorial Currents. (U.S. Navy, 1962, 1964).

The eastward-flowing Equatorial Countercurrent lies north of the Equator generally between 4° N and 9° N, most commonly between 5° N and 8° N. Current flow ranges between 0.4 knots and 2 knots per hour. The boundaries between this 300-mile wide Countercurrent and the North and South Equatorial Currents are well defined; however, at times water from either equatorial current may pass into the countercurrent (U.S. Navy, 1962, 1964). A spiral circulation of water occurs along these boundaries. Convergence at the southern boundary of the Equatorial Countercurrent and divergence at its northern boundary result in sinking and upwelling, respectively. This continual turnover of water, and the nutrients thus carried, creates narrow but well-defined zones of increased productivity (King, 1967; see also Reid, 1962, and Roden, 1963).

The ocean currents in the Marshall-Gilbert area indirectly affect seabird distribution. Oceanic upwellings increase the concentration of nutrients which in turn influence the food of many seabirds. This is discussed further under the Food Section.

Food

The amount of food available to seabirds in the Marshall-Gilbert area, as elsewhere, is related in an indirect way to the concentration of nutrient salts dissolved in the water. These salts are not distributed evenly, but are concentrated in some areas due to sea water circulation such as at the boundaries of the Equatorial Countercurrent. The nutrient salts are taken up by microscopic planktonic animals which are in turn eaten by larger invertebrates and fish. Birds are attracted to such areas because of the abundance of the latter. They feed on the small fish or squid which have been driven to the surface by still larger fish (King, 1967); therefore, large flocks of seabirds, particularly terns and noddies, are frequently seen above schools of tuna.

Very little is known about the food preferences of seabirds in the Marshall-Gilberts. Food samples were taken from most birds collected during the 1964 and 1967 POBSP Marshall-Gilbert visits. These samples have not, as yet, been analyzed.

Further at-sea data are needed throughout the Marshall-Gilbert area to discover if the boundaries of the Equatorial Countercurrent are a major feeding ground for area seabirds.

The food preference of area land and fresh-water birds is entirely different from that of seabirds. Most eat insects, crustaceans, and small lizards; a few eat seeds, grain, and fruit. All of these food elements are found throughout the Marshall-Gilbert area.

Predation

Man

The 1964 population of the Marshall Islands was 18,204 people (U. S. State Department, 1965), while the most recent (1950) population count of the Gilbert Islands showed 29,830 people (Catala, 1957). An average of 759 people (260 per square mile) live on each of the Marshall Islands; an average of 1,864 people (261 people per square mile) live on each of the Gilbert Islands (Table 41).

Although the average number of people per square mile is similar in both island groups, there is an increase from Zone 1 to Zone 5 (0; 0; 40; 245; 435 people per square mile, respectively), a decrease in Zone 6 (247 people per square mile), and a high of 468 people per square mile in Zone 7. There is a decrease in Zone 8 (221 people per square mile) and a slight increase in Zone 9 (271 people per square mile). The distribution of people follows a pattern similar to that of rainfall and vegetation. The location of major ports (Kwajalein, Majuro, Makin, and Tarawa) has a bearing on the number of people per zone.

Man has greatly affected the bird distribution throughout the Marshall-Gilbert area. Man has established himself in the more economically favorable regions of the area, namely those zones that have sufficient rainfall to produce a good coconut crop. Man has planted more and more coconut trees in these zones. As man's numbers have increased, original vegetation has gradually been reduced. This in turn has reduced the available niches in which the different bird species nest. Some species have adapted to nesting in coconut trees (White Tern, Brown Noddy, White-tailed Tropicbird); others, mainly ground-nesters, have been driven to small islets within the atoll or completely away to other atolls.

Many Marshallese and Gilbertese, even today, eat wild birds and their eggs. Early Marshallese knew that the northernmost of the Marshall Islands - Taongi and Bikar - were the breeding grounds for thousands of seabirds. Instead of visiting these islands year-round, they set them aside as bird sanctuaries and only visited them two or three times a year for gathering eggs, birds, and turtles. Other islands such as Jemo were also considered as bird sanctuaries. Even small islands within atolls (such as Eniwetak at Kwajalein) were regarded as bird sanctuaries (Fosberg, 1957). Taongi and Bikar, today, are infrequently visited by the Marshallese for egg and bird collecting. Islands within Taka and Jaluit Atolls are also still considered to be bird sanctuaries. It is hoped that all of these will remain as such.

Other Animals

Mammals -- Six species of mammals, besides man, occur in the Marshall-Gilbert area. These are pigs, dogs, cats, and three rodents. The first

three are recent introductions and occur on most islands where man is found. On some islands feral dogs and cats exist. Two of the rodents, Mus musculus, the House Mouse, and Rattus rattus, the Roof Rat, also are recent introductions and occur on islands inhabited by man, especially those with major ports. One rodent, Rattus exulans, occurs throughout the Marshall and Gilbert area. It was probably brought to the area as a stowaway aboard the canoes and vessels of early man.

Although all six of these mammals are potential predators of birds, only the feral cats and the two rat species are important in this respect. Feral cats, especially when present in high numbers, can reduce or destroy entire bird populations (Humphrey, 1965). Both rat species eat bird eggs and young. Rattus exulans has been known to kill adult albatrosses elsewhere in the Pacific (Kepler, 1967). Since Rattus exulans exists throughout the Marshall-Gilbert area, it possibly affects the distribution of some bird species, especially those which occur in small numbers.

Birds -- No birds of prey are known to occur in the Marshall-Gilbert area. Fosberg (1967), however, reported finding what was possibly an owl pellet at Jemo Island in December 1951. The Great Frigatebird, especially the adult female and subadult, are known to prey on the young of other birds such as the Sooty Terns and Brown Noddies. This predaceous activity has not, as yet, been observed in the Marshall-Gilbert area.

Reptiles -- Eight species of lizards, including skinks and geckoes, occur in the Marshall-Gilberts. Very few have been collected, thus, the species involved and distribution of each is unknown. Marshall (1956), Woodbury (1962), and Moul (1954) reported lizards from, respectively, Arno Atoll (6 species), Eniwetok Atoll (5 species), and Onotoa Atoll (2 species). POBSP personnel collected lizards from the area in 1964 and 1967.

An unidentified blind snake has been reported from Eniwetok Atoll (Woodbury, 1962). No snakes occur elsewhere in the Marshall-Gilberts.

Of the 9 reptile species that occur in the Marshall-Gilberts only the Monitor Lizard, Varanus indicus, is known to prey on birds and their eggs. This very large lizard is present only at Eniwetok, where it was introduced by the Japanese (Fosberg, 1956; Woodbury, 1962). Some birds probably eat the smaller lizards. Golden Plover, for example, have been known to eat lizards on other Central Pacific islands (Clapp, 1967).

Two turtle species, the Green Sea Turtle, Chelonia mydas, and the Hawkbill, C. imbricate, occur in the Marshall-Gilbert area. Green Sea Turtles are very numerous in the northernmost Marshalls, especially at Bikar (Fosberg, 1956). During egg laying, adult sea turtles may destroy the nests of ground or low-nesting birds. This has not been observed in the Marshall-Gilberts, but has been observed in the Leeward Hawaiian Islands (POBSP unpublished data).

Invertebrates -- Of the many invertebrates that occur throughout the Marshall-Gilbert area, crabs are the only group that may be considered bird predators. Two hermit crabs, the common Soldier Crab (*Coenobita rugosa*) and the Coconut Crab (*Birgus latro*) will eat both bird eggs and young birds.

Appendix A. Bird Banding and Movement within the Marshall-Gilbert area.

Over 2,000,000 birds have now been banded, using U.S. Fish and Wildlife bands, in the Central Pacific by POBSP personnel. Birds, totaling 6,874, of 16 species have been banded in the Marshall-Gilbert area. In 1964, POBSP personnel banded 5,353 birds of 13 species within this area. In addition, 1,523 bands (obtained from the POBSP) were placed on 5 species of birds at Eniwetok Atoll by Bowling Green State University personnel during 1965 and 1967. Data for these bands are listed below.

Species	Taongi	Bikar	Eniwetok	Jemo	Erikub	Makin	Total
Wedge-tailed Shearwater	499	-	-	-	-	-	499
Red-tailed Tropicbird	36	35	-	-	-	-	71
White-tailed Tropicbird	-	6	-	-	-	-	6
Blue-faced Booby	106	106	-	-	-	-	212
Red-footed Booby	335	376	-	-	-	-	711
Brown Booby	24	167	-	-	46	-	237
Great Frigatebird	1	10	-	-	-	-	11
Golden Plover	76	1	-	5	-	1	83
Bristle-thighed Curlew	11	1	-	-	-	-	12
Wandering Tattler	1	-	-	-	-	-	1
Black-naped Tern	-	-	1	-	-	-	1
Sooty Tern	2091	1400	1171	-	-	-	4662
Blue-gray Noddy	-	1	-	-	-	-	1
Brown Noddy	-	-	314	-	-	-	314
Black Noddy	-	-	12	-	-	-	12
White Tern	16	-	25	-	-	-	41
TOTAL	3196	2103	1523	5	46	1	6874

Very little is known of bird movements within the Marshall-Gilbert area. Woodbury (1963) marked 151 birds of 4 species with colored plastic strips on 4 May 1963. Three of these (2 Brown Noddies, 1 Sooty Tern) later were observed at Jaluit Atoll. Another, an adult Brown Noddy, appeared at Johnston Atoll in the late summer of 1963. This same individual or another was captured and banded (USF&W #753-26101) at Johnston Atoll on 10 June 1964 (first seen unbanded 11 August 1963); this bird was sitting on an egg when banded at Johnston.

Thirty-nine banded birds of eight species are now known to have moved to or within the Marshall-Gilbert area. Data for these are listed below.

Band No.	Location of banding	Age	Sex	Date of banding	Location of recovery	Date of recovery
Laysan Albatross						
737-96545	Kure	A	U	03-26-65	Mejit	06-early-65
Blue-faced Booby						
737-23929	Birnie	A	U	02-22-64	Nikunau	10-?-64
757-65528	Phoenix	I	U	11-03-64	Makin	02-09-66
568-71340	Howland	L	U	07-22-64	Makin	10-05-64
Red-footed Booby						
727-86501	Howland	I	U	10-19-63	Jaluit	12-29-64
747-54951	Enderbury	A	U	11-19-63	Jaluit	04-05-65
747-55040	Wake	I	U	01-05-65	Likiep	07-31-65
757-25658	Laysan	I	U	08-09-65	Namu	04-08-66
Brown Booby						
737-45292	Kure	I	U	10-04-63	Majuro	04-17-64
737-80545	Bikar	A	M	10-14-64	Likiep	07-31-65
737-80678	Bikar	A	M	10-17-64	Likiep	07-31-65
Great Frigatebird						
737-44881	Johnston	A	M	08-19-65	Wotje	04-01-67
737-49162	Enderbury	N	U	11-18-63	Arorae	10-08-64
Lesser Frigatebird						
747-58262	Howland	N	U	10-11-64	Tarawa	04-05-65
747-58298	Howland	N	U	10-11-64	Maiana	08-17-65
747-63125	Phoenix	N	U	11-04-64	Tamaroa	04-13-65
747-63560	Phoenix	N	U	11-06-64	Arorae	06-15-65
Ruddy Turnstone						
652-48214	St. George*	I	U	08-21-64	Majuro	09-26-64
652-48520	"	A	U	08-22-64	Mejit	09-15-64
652-48706	"	A	U	08-22-64	Arno	05-30-65
652-48906	"	I	U	08-24-64	Majuro	10-03-64
652-49049	"	I	U	08-26-64	Jaluit	11-01-64
652-49186	"	I	U	08-31-64	Makin	11-14-64
652-49262	"	I	U	08-27-64	Majuro	10-16-64
652-49559	"	A	U	09-02-64	Ailinglapalap	09-18-64
712-05074	"	A	U	08-10-65	Kwajalein	01-19-66
712-05256	"	A	U	08-11-65	Jaluit	09-10-66
712-06168	"	A	U	08-21-65	Kwajalein	05-?-66
712-06518	"	A	U	08-23-65	Majuro	10-04-66
712-07274	"	A	U	08-26-65	Arno	10-18-65
712-07926	"	A	U	09-24-65	Majuro	10-04-66
722-13867	"	I	U	08-18-66	Majuro	11-19-66
722-15253	"	I	U	08-23-66	Majuro	09-28-66
722-15899	"	A	U	08-25-66	Jaluit	10-01-66

*Alaska

Band No.	Location of banding	Age	Sex	Date of banding	Location of recovery	Date of recovery
722-16382	St. George	I	U	08-30-66	Jaluit	12-01-66
722-17067	"	A	U	09-01-66	Mili	06-?-66
722-17562	"	I	U	09-04-66	Majuro	09-28-66
1103-03434	"	A	U	08-26-67	Lib	09-26-67

Sooty Tern

903-34664	Laysan	A	U	06-12-66	Kwajalein	06-21-67

Appendix B. Native names of common birds found in the Marshall and Gilbert Islands.

Scientific	English	Gilbertese*	Marshallese**
<u>Diomedea</u> <u>nigripes</u>	Black-footed Albatross	---	Le [l^{y}eiy]
<u>Diomedea</u> <u>immutabilis</u>	Laysan Albatross	---	Le [l^{y}eiy]
<u>Pterodroma</u> <u>alba</u>	Phoenix Petrel	Tangiuoua	---
<u>Puffinus</u> <u>pacificus</u>	Wedge-tailed Shearwater	Korobaro	?
<u>Puffinus</u> <u>griseus</u>	Sooty Shearwater	?	Mentil [$m^{y}an^{y}teil^{y}$]
<u>Puffinus</u> <u>tenuirostris</u>	Slender-billed Shearwater	?	Mentil [$m^{y}an^{y}teil^{y}$]
<u>Puffinus</u> <u>nativitatus</u>	Christmas Shearwater	Tinebu	?
<u>Puffinus</u> <u>lherminieri</u>	Audubon's Shearwater	Nna	---
<u>Nesofregatta</u> <u>albigularis</u>	White-throated Storm Petrel	Bwebwe-ni-marawa	---
<u>Phaethon</u> <u>rubricauda</u>	Red-tailed Tropicbird	Taake	Lokwäjik [l^{y}awqayjik]
<u>Phaethon</u> <u>lepturus</u>	White-tailed Tropicbird	Ngutu	Jibkorej [jipkewrej] Jikorej [jiykewrej]
<u>Sula</u> <u>dactylatra</u>	Blue-faced Booby	Mouakena	Lellap [$l^{y}eil^{y}l^{y}$ap]
<u>Sula</u> <u>sula</u>	Red-footed Booby	Kota	Nana [$n^{y}ahn^{y}$ah]
<u>Sula</u> <u>leucogaster</u>	Brown Booby	Kibui	Kalo [kahlew] Tol [tal^{w}] (E)
<u>Fregata</u> <u>minor</u>	Great Frigatebird	Eitei	Ak [hak] Torlöñ [$tewerl^{y}$eig]
<u>Fregata</u> <u>ariel</u>	Lesser Frigatebird	Eitei	Ak [hak]

Appendix B. Native names of common birds found in the Marshall and Gilbert Islands (cont.).

Scientific	English	Gilbertese*	Marshallese**
<u>Egretta</u> <u>sacra</u>	Reef Heron	Kaai	Kabaj [kahbaj]
<u>Anas</u> <u>platyrhynchos</u>	Mallard	Tiriwenei	Roñanbat [rag^{w}an^{y}pat]
<u>Anas</u> <u>clypeata</u>	Northern Shoveler	Tiriwenei	Roñanbat [rag^{w}an^{y}pat]
<u>Pluvialis</u> <u>dominica</u>	Golden Plover (breeding plumage) (nonbreeding plumage)	Kun	 Kolej [qel^{y}yej] Lakeke [lakeiykeiy]
<u>Numenius</u> <u>phaeopus</u>	Whimbrel	?	Kowak [kewwak]
<u>Numenius</u> <u>tahitiensis</u>	Bristle-thighed Curlew	Kewe	Kökkök [kekkek]
<u>Limosa</u> <u>lapponica</u>	Bar-tailed Godwit	Kaka	?
<u>Heteroscelus</u> <u>incanum</u>	Wandering Tattler	Kiriri	Kidrid [kidid]
<u>Arenaria</u> <u>interpres</u>	Ruddy Turnstone (breeding plumage) (nonbreeding plumage)	Kitiba	Kötköt [ketket] (general term) Aerär [hayerayar] (W) Ula [wil^{y}ah] (E) Nakdrid [n^{y}akdid] (W) Na [n^{y}ah] (E)
<u>Crocethia</u> <u>alba</u>	Sanderling	?	Kwöl [qel^{y}]
<u>Sterna</u> <u>sumatrana</u>	Black-naped Tern	Kiakia	Kear [keyyar] Kear-drik [keyyar-dik]
<u>Sterna</u> <u>lunata</u>	Gray-backed Tern	Tarangongo	?
<u>Sterna</u> <u>fuscata</u>	Sooty Tern	Keeu (Kereekere)	Memej [m^{y}m^{y}eij] (E) O [wewew] (W)

Appendix B. Native names of common birds found in the Marshall and Gilbert Islands (cont.).

Scientific	English	Gilbertese*	Marshallese**
Thalasseus bergii	Crested Tern	Karakara (Kabiniwa)	Kear [keyyar] Kear-lab [keyyar-lap] (W) Kear-mwit [keyyar-meit] (E)
Procelsterna cerulea	Blue-gray Noddy	---	La̍un Bikar [l^yawin^y pikahar]
Anous stolidus	Brown Noddy	Lo, Io	Bijwak [peijwak]
Anous tenuirostris	Black Noddy	Mangkiri	Jekad [jekad]
Gygis alba	White Tern	Matawa	Mejo [m^yajaw] Jui [jiwiy] (NW)
Gallicolumba erythroptera	Ground Dove	Bitin	---
Ducula oceanica	Micronesian Pigeon	Rube	Mule [mil^weiy]
Urodynamis taitensis	New Zealand Cuckoo	Kabenei	Udel [wideij]
Asio flammeus (?)	Short-eared Owl	---	Lijemao [l^yijeiymahwew]

* Adapted from Child (1960)

** Traditional spelling given first, followed by phonemicization in brackets. Phonemicization follows in general that used in Bender (in press). Abbreviations E, W, NW in parenthesis indicate variants: eastern, western, northwestern.

LITERATURE CITED

Agassiz, A. 1903. The coral reefs of the tropical Pacific. Mem. Mus. Comp. Zool. 28:1-410, plus 2 vol. plates.

Alexander, W. B. 1928. Birds of the Ocean. G. P. Putnam's Sons, New York.

Alexander, W. B. et al. 1965. The families and genera of the petrels and their names. Ibis 107:401-405.

Amadon, D. 1943. Notes on some non-passerine genera, 3. Amer. Mus. Novit. 1237:1-22.

American Ornithologists' Union. 1957. Checklist of North American birds. 5th ed. Lord Baltimore Press, Baltimore.

Anderson, D. 1951. The plants of Arno Atoll, Marshall Islands. Atoll Res. Bull. 7:1-4, i-vii.

Ashmole, N. P. 1963. The biology of the Wideawake or Sooty Tern Sterna fuscata on Ascension Island. Ibis 103b:297-364.

Baker, R. H. 1948. Report on a collection of birds made by U.S. Naval Medical Research Unit No. 2 in the Pacific war area. Smithsonian Misc. Coll. 107(15):1-74.

Baker, R. H. 1951. The avifauna of Micronesia, its origin, evolution, and distribution. Univ. of Kansas Pub., Mus. of Nat. Hist. 3:1-359.

Bender, B. W. (in press). Spoken Marshallese: an intensive course with gramatical notes and glossary. Univ. Hawaii Press, Honolulu.

Bent, A. C. 1929. Life histories of North American shore birds (part 2). U.S. Nat. Mus. Bull. 146:1-412, i-ix.

Blumenstock, D. I. 1958. Typhoon effects at Jaluit Atoll in the Marshall Islands. Nature 4645:1267-1269.

Blumenstock, D. I. (ed.), 1961. A Report on typhoon effects upon Jaluit. Atoll Res. Bull. 75:1-105.

Bock, W. J. 1958. A generic review of the plovers (Chardriinae, Aves). Bull. Mus. Comp. Zool. 118:27-97.

Bogert, C. 1937. Birds collected during the Whitney South Sea Expedition. xxxiv. The distribution and the migration of the Long-tailed Cuckoo (Urodynamis taitensis, Sparrman). Amer. Mus. Novit. 993:1-12.

Bourne, W. R. P. in R. O. Morris. 1963. The birds of the Gilbert Islands. Sea Swallow 16:79-83.

Bruyns, W. F. J. 1964. Birds seen during west to east Trans-Pacific Crossing along Equatorial Counter-current around Latitude 7° N. in the autumn of 1960. Sea Swallow 17:57-66.

Bryan, E. H., Jr. 1958. Check list and summary of Hawaiian birds. Books about Hawaii, Honolulu.

----- 1965. Birds of the Marshalls. The Marshalls and the Pacific, No. 6. Hourglass Special, Kwajalein (mimeographed), 2pp.

Catala, R. L. A. 1957. Report on the Gilbert Islands: Some Aspects of Human Ecology. Atoll Res. Bull. 59:1-187.

Chamisso, A. von. in von Kotzebue. 1821. A voyage of discovery into the South Sea and Bering Straits. 3 vols. Longman et al., London 2:351-433; 3:1-318.

Child, P. 1960. Birds of the Gilbert and Ellice Islands colony. Atoll Res. Bull. 74:1-38.

Clapp, R. B. and F. C. Sibley. 1967. New distributional records of birds from the Phoenix and Line Islands. Ibis 109:122-125.

Clapp, R. B. and G. M. Tilger. 1967. Predation on Snake-eyed Skink, *Ablepharus boutini*, by two Pacific Shorebirds. Herpetologica 23(1): 75.

Clapp, R. B. and P. W. Woodward. 1968. New records of birds from the Hawaiian Leeward Islands. U.S. Nat. Mus. 124(3640):39.

Cloud, P. E., Jr. 1952. Preliminary report on the geology and marine environments of Onotoa Atoll, Gilbert Islands. Scientific Investigation in Micronesia Rept. 12:1-73. Washington (mimeographed).

Cox, D. C. 1951a. The hydrology of Arno Atoll. Scientific Investigation in Micronesia Rept. 9:1-29. Washington (mimeographed).

----- 1951b. The Hydrology of Arno Atoll, Marshall Islands. Atoll Res. Bull. 8:1-29.

Cross-cultural Survey. Institute of Human Relations, Yale Univ. 1943. Food and water supply in the Marshall Islands. Strategic Bull. of Oceania 5:1-24. Washington (mimeographed).

Delacour, J. 1954. The Waterfowl of the World. Vol. 1. Country Life Ltd., London.

----- 1959. The Waterfowl of the World. Vol. 3. Country Life Ltd., London.

Doran, E., Jr. 1959. Pacific Missile Range, Point Mugu, Calif. Miscellaneous Publication No. PMR-MP-59-30. Handbook of Selected Pacific Islands. Pp. 1-64.

Findlay, A. G. 1886. A directory for the navigation of the North Pacific Ocean, with descriptions of its coasts, islands, etc., from Panama to Behring Strait and Japan; its winds, currents, and passages. 3rd ed. Richard Holmes Laurie, London.

Finsch, O. 1880a. Beobachtungen uber die Vogel der Inseln Ponape (Carolinen). Journ. f. Ornith. 28:283-295.

----- 1880b. Beobachtungen uber die Vogel der Inseln Kuschai (Carolinen). Journ. f. Ornith. 28:296-310.

----- 1880c. Ornithological letters from the Pacific. No. II. Taluit (Bonham) Island. Ibis 4th ser., 4:218-220.

----- 1880d. Ornithological letters from the Pacific. No. III. Taluit (Bonham) Island. Ibis 4th ser., 4:329-333.

----- 1884. Uber Vogel der Sudsee. Auf Grund eigener beobachtungen and Sammlungen. Mitt. Ornith. Ver. Wien, V. Micronesia: 46-56.

----- 1893a. Ueber die Monasaralle von Kuschai (Kittlitzia Monasa [Kittlitz] and die bisher mit ihr verweschselten Arten). Mitth. Ornith. Ver. Wien, "Die Schwalbe." 17:1-5.

----- 1893b. Einiges uber Sudsee-Rallen. Anzeigeblatt Ornith. Monats. des. Deut. Ver. z. Schutze der Vogelwelt. 18:457-463.

Fisher, H. I. 1946. The type localities of Puffinus pacificus cuneatus Salvin and Pterodroma leucoptera hypoleuca (Salvin). Auk 63:587-588.

Fosberg, F. R. 1954. Soils of the Northern Marshall Atolls with special reference to the Jemo Series. Soil Sci. 78(2):99-107.

----- 1955. Northern Marshall Islands Expedition, 1951-1952. Atoll Res. Bull. 38:1-37, 39:1-22.

----- 1956. Military geography of the northern Marshall Islands. (Mimeo. report, U.S. Army Chief of Engineers, Washington, D.C.).

----- 1957. Lonely Pokak. Living Wilderness 62:1-4.

----- 1966. Marshall Islands land biota II: birds. Atoll Res. Bull. 114:1-35.

Fosberg, F. R. in Blumenstock. 1961. A Report on typhoon effects upon Jaluit. Atoll Res. Bull. 75:1-103.

Gleize, D. A. and D. Genelly. 1945. With the colors. Bull. Mass. Audubon Soc. 29:221-222.

Greenway, J. C., Jr. 1952. Tricholimnas conditicus is probably a synonym of Tricholimnas sylvestris. Breviora 5:1-4.

348-415 O-69—23

Gressitt, J. L. in Blumenstock. 1961. A Report on typhoon effects upon Jaluit. Atoll Res. Bull. 75:69-73.

Hager, C. 1885. Die Marshall-Inseln in Erd-und Volkerkunde, Handel, und Mission, mit einen Anhang: Die Gilbert-Inseln, Leipzig.

Hatheway, Wm. H. 1957. Agricultural notes on the Southern Marshall Islands, 1952. Atoll Res. Bull. 55:1-9.

Humphrey, P. S. 1965. Smithsonian Year. Smithsonian Press, Washington, D. C.

Kenady, R. M., Jr. 1962. The soils of Rongelap Atoll, Marshall Islands. MS thesis, Univ. of Washington, Seattle.

Kepler, C. B. 1967. Polynesian Rat predation upon nesting Laysan Albatross and other Pacific seabirds. Auk 84(3):426-430.

King, W. B. 1967. Preliminary Smithsonian identification manual. Sea-birds of the Tropical Pacific Ocean. Smithsonian Institution Press, Washington, D.C.

Kramer, A. and H. Nevermann. 1938. Ralik-Ratak (Marshall-Inseln) in G. Thilenius, Erg. Suds. Exp. II B 11:1-304.

Kuroda, N. in Momiyama. 1922. Birds in Micronesia. A list of the birds of the Micronesian Group. Ornith. Soc. Japan 1:31-78.

Kuroda, O. 1934. On the Ookiashishigi (new name) (Greater Yellowshank) Dobutsugaku Zasshi 46(549).

Luomala, K. 1953. Ethnobotany of the Gilbert Islands. Bishop Mus. Bull. 213:1-129.

Mackenzie, J. B. in Blumenstock. 1961. Population and economy of Jaluit. Atoll Res. Bull. 75:81-88.

Marshall, C. 1956. Long term meteorological variation and their effects on land uses in small South Pacific Islands. Proc. 8th Pac. Sci. Cong. 2A:1129-1135.

Marshall, J. T., Jr. 1951. Vertebrate ecology of Arno Atoll, Marshall Islands. Atoll Res. Bull. 3:1-38.

----- 1955. Rats of Arno Atoll, Marshall Islands. J. Mammal. 36:259-263.

----- 1957. Atolls visited during the first year of the Pacific Islands Rat Ecology Project. Atoll Res. Bull. 56:1-11.

Mason, L. in Freeman, O. T. 1951. Geography of the Pacific. John Wiley, New York.

Mathews, G. M. 1933. Additions and corrections to the 'Systema Avium Australasianarum', III. Ibis 13th ser. 2:132-161.

Mayr, E. 1940. Speciation phenomena in birds. Amer. Nat. 74:249-278, 7 figs.

----- 1945. Birds of the Southwest Pacific. MacMillan Co., New York.

Momiyama, T. 1922. Birds of Micronesia. The Ornith. Soc. Japan 1:1-24.

Morris, R. O. 1963. The birds of the Gilbert Islands. Sea Swallow 16:79-83.

Moul, E. T. 1954. Preliminary report of the land animals at Onotoa Atoll, Gilbert Islands. Atoll Res. Bull. 28:1-28.

----- 1957. Preliminary Report on the Flora of Onotoa Atoll, Gilbert Islands. Atoll Res. Bull. 57:1-48

Murphy, R. C. 1951. The populations of the Wedge-tailed Shearwater (Puffinus pacificus). Amer. Mus. Novit. 1512:1-21.

North, A. J. 1894. Oological Notes. [Cuculidae, Meliphagidae]. T. c. pp. 39-42.

----- 1896. On the Habits of a Cuckoo in the Gilbert Islands. Proc. Zoo. Soc. London 1896:934-935.

Ornithological Society of Japan. 1932. A hand-list of Japanese birds. Revised. Yamashina Inst. for Ornith. and Zool., Tokyo.

----- 1942. A hand-list of Japanese birds. 3rd ed. revised. Yamashina Inst. for Ornith. and Zool., Tokyo.

----- 1958. A hand-list of Japanese birds. 4th ed. revised. Yamashina Inst. for Ornith. and Zool., Tokyo.

Oustalet, M. E. 1896. Les mammiferes et les oiseaux des iles Mariannes. Nouvelles Archives Mus. d'Hist. Nat. (Paris) 8:25-74.

Pearson, A. J. 1962. Field notes of the birds of Ocean Island and Nauru during 1961. Ibis 104:421-424.

Pearson, D. L. and J. W. Knudsen. 1967. Avifauna records from Eniwetok Atoll, Marshall Islands. Condor 69:201-203.

Peters, J. L. 1931. Check-list of birds of the World. Vol. I. Harvard Univ. Press, Cambridge, Mass.

----- 1934. Check-list of birds of the World. Vol. II. Harvard Univ. Press, Cambridge, Mass.

Peters, J. L. 1937. Check-list of birds of the World. Vol. III. Harvard Univ. Press, Cambridge, Mass.

Peters, J. L. and L. Griscom. 1928. A new rail and a new dove from Micronesia. Proc. New England Zool. Club 10:99-106.

Phillips, J. C. 1923. A natural history of the ducks. Houghton Mifflin Co., Boston and New York.

Reichenow, A. 1901. Eine auffallende Vogelzustrasse vom nordwestlichen Nordamerika nach Polynesien. Ornith. Monatsber. 9:17-18.

Reid, J. L., Jr. 1962. On circulation, phosphate-phosphorus content, and zooplankton volumes in the upper part of the Pacific Ocean. Limn. and Ocean. 7:287-306.

Richardson, F. and H. L. Fisher. 1950. Birds of Moku Manu and Manana Islands off Oahu, Hawaii. Auk 67:285-306.

Ripley, S. D. and H. Birckhead. 1942. On the fruit-pigeons of the Ptilinopous purpuratus group. Amer. Mus. Novit. 1192:1-14.

Roden, G. I. 1963. On sea level temperature and salinity variations in the Central Tropical Pacific and on Pacific Ocean Islands. J. Geophysical Res. 68:455-472.

Sachet, M-H. 1957. Climate and Meteorology of the Gilbert Islands. Atoll Res. Bull. 60:1-4 + Tables A-E.

Salvin, O. 1888. Critical notes on the Procellariidae. Ibis, 3d ser. 6:351-360.

Schnee, P. von. 1901. Eine auffallende Vogelzustrasse vom nordwestlichen Nordamerika nach Polynesien. Ornith. Monatsber 9:131-132.

Sibley, F. C. and R. B. Clapp. 1967. Distribution and dispersal of Central Pacific Lesser Frigatebirds. Ibis 109:328-337.

Stone, L. E., Jr. 1951. The soils and agriculture of Arno Atoll, Marshall Islands, Atoll Res. Bulls. 5,6.

Takatsukasa S. and Y. Yamashina. 1932. Second report on birds of the South Sea. Dobutsu. Zasshi 44:221-226.

Taylor, W. R. 1950. Plants of Bikini and other northern Marshall Islands. Univ. Mich. Press, Ann Arbor.

Townsend, C. H. and A. Wetmore. 1919. Reports of the scientific results of the expedition to the Tropical Pacific in charge of Alexander Agassiz on the U.S. Fish Commission Steamer "Albatross" from August 1899 to March 1900, Commander Jefferson F. Moser, U.S.N., commanding. XXI. The Birds. Bull. Mus. Comp. Zool. 63:151-225.

Udvardy, M. D. F. 1961a. Continental migrants and shore birds on Oahu, during 1958-1959. Elepaio 21:47-50.

----- 1961b. Additions to the check list of Hawaiian birds. Elepaio 21:83-90.

U.S. Department of the Navy. 1943. Handbook of the Marshall Islands. Military Govt. Handbook. OPNAV 50E-1:1-113.

----- 1952. Sailing directions for the Pacific Islands Vol. III. The south-central groups. U.S. Naval Oceanographic Office, Washington, D. C. H. O. Pub. No. 80, 6th ed.

----- 1964. Sailing directions for the Pacific Islands Vol. I. Western groups, including the Solomon Islands. U.S. Naval Oceanographic Office, Washington, D.C. H.O. Pub. No. 82, 2nd ed.

----- 1966. Sailing directions for the Pacific Islands. Vol. III. Change 9. The south-central groups. U.S. Naval Oceanographic Office, Washington, D.C. H.O. Pub. No. 80, 6th ed.

U.S. Department of State. 1965. Trust Territory of the Pacific Islands. 18th Annual Report to the United Nations on the Administration of the Trust Territory of the Pacific Islands. July 1, 1964 to June 30, 1965.

Watson, G. E., III. 1966. Seabirds of the Tropical Atlantic Ocean, Smithsonian Institution, Washington, D. C.

Wiglesworth, L. W. 1891a. Aves Polynesiae. A catalogue of the birds of the Polynesian subregion. Abhandl. und Ber. Zool. Mus. Dresden 6:vi, 1-92.

----- 1891b. On the Polynesian members of the genus Ptilopus. Ibis 6th ser. 3:566:584.

----- 1893. Remarks on the birds of the Gilbert Islands. Ibis 6th ser. 5:210-215.

Wiens, H. J. 1957. Field Notes on Atolls Visited in the Marshalls. Atoll Res. Bull. 54:1-23.

----- 1962. Atoll environment and Ecology. Yale Univ. Press, New Haven.

Woodbury, A. N. 1962. A review of the ecology of Eniwetok Atoll, Pacific Ocean. Univ. of Utah Biol. Series 1-137.

Woodford, C. M. 1895. The Gilbert Islands. Geog. Jour. 6:325-350.

Yamashina, Y. 1932a. On a collection of birds' eggs from Micronesia. Tori 7:393-413.

Yamashina, Y. 1932b. On the distribution of the birds in Micronesia. Bull. Biogeogr. Soc. Japan 3:139-148, pls. 8-12.

----- 1940. Some additions to the "List of the birds of Micronesia." Tori 10:673-679.

----- 1948. Notes on the Marianas Mallard. Pacific Science 2:121-124.

----- 1961. Birds in Japan. A Field Guide. Tokyo News Service, Ltd., Tokyo.

Yocom, C. F. 1964. Waterfowl wintering in the Marshall Islands, southwest Pacific Ocean. Auk 81:441-442.

U.S. GOVERNMENT PRINTING OFFICE : 1969 O—348-415